CENTRAL ASIA NATURAL RESOURCES MANAGEMENT PROGRAM

TRANSBOUNDARY WATER AND ENERGY PROJECT

# AN ASSESSMENT OF KAMBARATA 1 AND 2 HYDROPOWER PROJECTS

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*Funded by:*

U.S. Agency for International Development
Regional Mission for Central Asia
Office of Energy and Water
Park Palace Building
41 Kazybek bi Street
Almaty, Kazakhstan 480091
(7-3272) 50-76-17

*Prepared by:*

PA Consulting Group
119 Ahunbaeva Street
Bishkek, Kyrgyzstan 720055
(996-312) 54-85-52

and

PA Government Services
1750 Pennsylvania Avenue NW
Suite 1000
Washington DC 20006-4506
(202) 442-2000

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## GLOSSARY

### ABBREVIATIONS

| | |
|---|---|
| **ADB** | Asian Development Bank |
| **CAPS** | Central Asian Power System |
| **CAR** | Central Asian Republics |
| **CHP** | Combined Heat and Power Plant |
| **EDR** | Equalizing discount rate |
| **ERR** | Economic rate of return |
| **HPP** | Hydro Power Plant |
| **ICWC** | Interstate Commission for Water Coordination |
| **IFI** | International Financial Institution |
| **JSC** | Joint Stock Company |
| **LS** | Lump Sum |
| **MUV Index** | Index of the Value of Manufactured Export |
| **NRMP** | Natural Resources Management Program |
| **PCCAR** | Power Council of Central Asia Republics |
| **SEA** | State Energy Agency |
| **TO** | Task Order |
| **TPP** | Thermal Power Plant |
| **TWEP** | Transboundary Water and Energy Project |
| **UDC** | Unified Dispatch Center |
| **UPSCAR** | United Power System of Central Asia Republics |
| **USAID** | United States Agency for International Development |
| **USAID/CAR** | USAID Mission for Central Asia |
| **WB** | World Bank |

### CURRENCY EQUIVALENTS

US$ 1 = 46,2 som (as of November, 2002)

## WEIGHTS AND MEASURERS

kWh = Kilowatt hour (= 860.42 kcals)
GWh = Gigawatt hour (one million kilowatt hours)
kW = Kilowatt (1,000 watts)
MW = Megawatt (1,000 kilowatts)
kV = Kilovolt (1,000 volts)
mcm = One million cubic meters
bcm = One billion cubic meters (One cubic kilometer)

## EQUATIONS

1 mcm of water under 1 meter of head = 2,724 kWh at 100% efficiency
1 cubic meter per second of water under meter of head = 9.81 kW at 100% efficiency

System Load Factor = Average Demand /Peak Demand for a given period of time.
Example: January 2000 energy demand for Kyrgyzstan = 1,606 GWh and January peak demand is 2,604 MW: the load factor is (1,606,000/744)/2,604,000 = 84%

Plant factor = Average Output/Peak Output of a power plant for a given period of time.
Example: If Kambarata 1 produces 398 GWh in September and can operate at 1,200 MW (reservoir full): the plant factor is (398/.720)/1,200 = 46%

## SUMMARY AND CONCLUSIONS

The Kambarata 1 Hydropower Project at a cost of about US$ 1.2 billion, an installed capacity of 1,200 MW and annual energy generation of 4,500 GWh would be competitive with a thermal power project in the future expansion of Kyrgyzstan's power system. Although Kambarata 1 has a higher initial capital cost than the thermal alternative, the avoided annual cost of fuel imports would be around US$100 million. The installed capacity could be increased to 1,600 MW, and even higher, to provide peaking capacity for the Central Asian Power System (CAPS).

The Kambarata 2 Hydropower Project at a cost of about US$ 280 million, an installed capacity of 400 MW and annual energy generation of 1,260 GWh could be a low-cost source of peaking power for export to South Kazakhstan or Uzbekistan as a part of the CAPS and increase Kyrgyzstan's summer hydro energy surplus.

Further study of the two projects is justified to refine designs and cost estimates, assess benefits in more detail, and to investigate possibilities for financing. Of particular interest would be a study of staged development of Kambarata 1 to bring the initial cost down to a level that might be more easily financed.

The basic problem with the Kyrgyzstan power system is that the hydropower projects of the Naryn Cascade (the 1,200 MW Toktogul dam and reservoir, and 1,670 MW of run-of-river hydropower plants), produce most of their energy in the summer, whereas the peak energy demand is in the winter months. The result is a high winter demand on the existing thermal power plants that requires large imports of fuel and energy. Consequently, the operators of Toktogul aim to maximize reservoir releases and energy production in the winter and minimize reservoir release to the downstream countries in the summer. To address this energy/irrigation conflict, the Syr Darya basin countries entered into the March 17, 1998 Framework Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin. Tajikistan became a party to this Agreement on June 19, 1998. This provides for winter fuel to be delivered to Kyrgyzstan in return for sales of hydro energy in the summer months.

This report looked at the effect on Kyrgyzstan's winter energy shortage of different operating regimes for the Toktogul Reservoir in the years before Kambarata 1 would be in service. It was found that none of the operating regimes, even the most extreme "power oriented regime", eliminates the need for large imports of fuel and energy under present conditions. By the Year 2005, with no additional capacity in service and average river flows, Kyrgyzstan will have an annual energy deficit of about 1,500 GWh, composed of a winter deficit of 3,900 GWh and a summer surplus of 2,400 GWh. The energy deficits have not reached these levels in the past because of unusually high reservoir inflows coupled with unsustainable withdrawals from the Toktogul Reservoir. Hydro energy generation has been 30% above sustainable levels. It is clear, therefore, that Kyrgyzstan's need for imports of fuel and energy will continue to grow until new capacity is installed.

The addition of Kambarata 1 would eliminate the winter deficits and thereby eliminate the conflict in the operation of the Toktogul Reservoir between the irrigation and environmental needs of the downstream countries and the winter energy needs of Kyrgyzstan. Kambarata 2 would add to Kyrgyzstan's summer hydro surplus that could be exchanged for fuel imports, but it would not significantly reduce the winter energy deficit.

Thus, the main elements of a power development plan for Kyrgyzstan should be:

- Rehabilitation of the existing thermal power plants at Bishkek and Osh to restore their capacity to 680 MW and 50 MW respectively.
- Continued imports of fuel and energy in return for exports of the summer hydro surplus under the 1998 Framework Agreement.
- Completion of the Kambarata 1 and Kambarata 2 Projects.
- An aggressive program to reduce losses from the present level of over 40% to no more than 18% (losses of 18% are assumed in the operation studies described in Chapter 6).
- A program to encourage consumers to move from electric heating to gas heating, and where possible coal heating.
- Investigation of Kyrgyzstan's of coal resources as a base for thermal power (in the 1980's, over one million tons of coal was mined in the Kyrgyzstan, but production is now down to 100,000 tons).

The adverse social and environmental impacts of Kambarata 1 and Kambarata 2 appear to be quite limited. The reservoirs are reported to have no permanent residents and only a few livestock herdsmen. Nevertheless, a detailed social and environmental assessment should be carried out.

A workshop was held in Bishkek on February 25-26, 2003 to seek the comments of Kyrgyzstan power sector officials on the report. This led to useful suggestions on technical issues and a valuable exchange of views on the regional aspects of the two projects. This report reflects the findings of the workshop.

Following discussions of the report with power sector officials in Kazakhstan, the next steps are likely to be as follows:

- Set up a Working Group of Kyrgyzstan and Kazakhstan experts to oversee the following activities.
- Prepare more detailed feasibility studies for the two projects. These would include an investigation of the possibility of staging Kambarata 1 including an analysis of different configurations of the 500 kV transmission network. The studies would present in more detail the costs and benefits of the projects and their contribution to the power systems of Kyrgyzstan and its neighbors, and their impact on water management.
- Investigate possible financing and institutional arrangements for further development of the projects.

# 1. INTRODUCTION

## 1.1 USAID Support to the Water and Energy Sector of the CAR

The strategy of the USAID Mission for Central Asia (USAID/CAR) is to support an improvement in the management of critical natural resources in the region through pilot projects to demonstrate good management and by training, public outreach and partnership development throughout the region. The strategy is being implemented by the Central Asia Natural Resource Management Program (NRMP).

The Transboundary Water and Energy Project (TWEP) under the NRMP supports activities that would help leaders in Central Asia develop and agree on measures to improve water and energy cooperation. TWEP focuses on the Syr Darya basin where a conflict has arisen between the energy needs of Kyrgyzstan and the irrigation needs of the downstream riparians. The Syr Darya basin is shared by Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan (see Figure 1).

Table 1.1 gives an overview of the current status of measures that could help reduce seasonal conflicting demands in the use of water for power and irrigation in the Syr Darya basin. Measures that could be realized in the short term include energy loss reduction in Kyrgyzstan and better interstate agreements on water and energy use. In the medium term, projects in Tajikistan, Uzbekistan and Kazakhstan could be completed aimed at the seasonal re-regulation of water releases in the Syr Darya basin. Development of the Kambarata hydropower projects in Kyrgyzstan could improve water and energy cooperation in the long-term. The implementation of the listed "engineering" and "trading" measures need to be complemented by the strengthening of interstate institutions.

**Table 1.1 Measures to improve regional water and energy cooperation.**

| Time Frame | Measures | Current Status |
|---|---|---|
| **Short-term** 0 - 2 years | Reduction of electricity losses in the Kyrgyz energy system | • National loss reduction program defined<br>• USAID and WB support its implementation |
| | Improvement of the implementation of the 1998 Framework Agreement | • USAID supports the development of the additional information required for meaningful discussions on the issue |
| | Improvement of coordination between water and energy dispatchers | • USAID supports needs assessment<br>• Possible follow-up by USAID and ADB |
| | Agreement on Power Trade Relations | • USAID supports the development of the agreement under the proposed Regional Power Transmission Modernization Project, supported by loans from the ADB and EBRD |
| | | |
| **Medium-** | Improvement of Chardara Reservoir (Kazakhstan) | • Implemented under the SYNAS project supported by a WB loan |

| | | |
|---|---|---|
| **term**<br>3 – 7<br>years | Improvement of carrying capacity Syr Darya downstream of Chardara | • Implemented under the SYNAS project |
| | Improvement of Kairakum Reservoir and surrounding irrigated areas (Tajikistan) | • Tajikistan, Uzbekistan, and Kazakhstan signed protocol to undertake feasibility study<br>• USAID and WB support project preparation |
| | Strengthening of interstate water management organizations | • Little progress has been made to date due to lack of political commitment |
| | Improvement of CA power transmission system | • US$175 million loan package from ADB and EBRD is being prepared<br>• Possible support from USAID for implementation of Power Trade Action Plan |
| | Further improvement of the Kyrgyz energy system | • First steps to create enabling environment to attract private investment have been taken |
| | Irrigation rehabilitation, groundwater development and drainage water reuse in Ferghana Valley (Uzbekistan) | • USAID and WB support project identification |
| | New storage reservoirs and water transfer projects in Uzbekistan | • Preparatory work has started |
| | | |
| **Long-term**<br>8 – 15<br>years | Construction of the Kambarata 1 and 2 hydropower projects (Kyrgyzstan) | • USAID supports an evaluation of both projects and the dialogue between basin states on the next steps |
| | Further improvement of the operations of interstate water and energy systems | |

### 1.2 Scope of this Report

This Report makes an assessment of the Kambarata 1 and Kambarata 2 hydropower projects in Kyrgyzstan using studies and data from the files of USAID, the World Bank, and several government agencies in the region. The Report looks at these projects in the context of Kyrgyzstan’s energy system and also the interconnected CAR high voltage transmission grid. Annual energy generation is estimated for the projects, singly or in combination, and earlier estimates of project costs have been updated. The projects are compared to alternative sources of power and energy.

The Report's purpose is to help officials in Kyrgyzstan and the other states of the CAR, and potential financing agencies to decide whether or not to proceed with a more detailed assessment of the costs and benefits of these projects.

# 2. THE POWER SYSTEM OF THE CENTRAL ASIAN REPUBLICS

## 2.1 The Present Situation

The Central Asian Power System (CAPS) comprises 85 power stations with an installed generating capacity of close to 25,000 MW, of which 9,000 MW is hydropower plants and around 16,000 MW thermal power plants (see Table 2.1). High-voltage transmission lines link the power systems of the five countries for parallel operation. A schematic layout of the 500 kV transmission lines is shown in Figure 2.

The dependable capacity is now about 21,000 MW because many of the thermal plants date back to the 1960s and cannot perform at their original capacity. Most of the thermal plants in Uzbekistan and Turkmenistan are conventional gas-fired steam plants. In Kyrgyzstan and Tajikistan the thermal plants are multi-fuel combined heat and power (CHP) plants. The plants in South Kazakhstan are coal-fired.

The major hydropower plants are located in Kyrgyzstan (mainly the Naryn Cascade, 2,870 MW) and in Tajikistan (4,000 MW including the 3,000 MW project at the Nurek Reservoir). The main power plants and load centers are connected by a 500 kV transmission grid system that is in need of rehabilitation. The main facilities of the CAPS are summarized below.

**Table 2.1 Central Asian Republics: Power Plants and Transmission Lines**

| **Country** | **Installed Capacity (MW)** | | |
|---|---|---|---|
| | Thermal | Hydro | Total |
| Kazakhstan (South) | 2,000 | 360 | 2,360 |
| Kyrgyzstan | 790 | 2,900 | 3,690 |
| Tajikistan | 300 | 4,000 | 4,300 |
| Turkmenistan | 2,600 | 0 | 2,600 |
| Uzbekistan | 9,800 | 1,700 | 11,500 |
| Totals | 15,490 | 8,960 | 24,450 |
| | **Transmission Lines (km)** | | |
| | 500kV | 220kV | |
| Kazakhstan (South) | 1,080 | 1,300 | |
| Kyrgyzstan | 541 | 1,252 | |
| Tajikistan | 300 | 1,200 | |
| Turkmenistan | 370 | 2,000 | |
| Uzbekistan | 1,700 | 5,100 | |
| Totals | 3,991 | 10,852 | |

Under the Soviet regime, the CAPS were operated as an integrated system under the control of the Unified Dispatch Center (UDC) at Tashkent. Surplus energy from the hydropower plants displaced thermal energy in the summer, and Kyrgyzstan and Tajikistan imported energy from the thermal plants in the winter. Also, Kyrgyzstan and Tajikistan imported fuel in the winter for their CHP plants. The CAPS acted like a single, self-contained utility company; no money changed hands for the imports of fuel and energy. In 1990, energy generation reached 112,500 GWh, but then dropped sharply, followed by a slow recovery to 92,000 GWh in 2001 and a peak load of 15,500 MW.

Since the early 1990s to the present time, the republics have operated their generating plants in many ways as five independent power systems. Power exchanges still take place, but at a lower level than in the 1980s, and the hydropower plants continue to provide frequency control and system stability. Kyrgyzstan still imports fuel in the winter and exports surplus hydro energy in the summer under annual agreements with Uzbekistan and Kazakhstan.

But the fuel deliveries fall short of Kyrgyzstan's needs; this has led to a cutback in the output of the CHPs that in turn has driven up the consumption of electricity for home heating. A similar situation prevails in Tajikistan. The response in Kyrgyzstan has been to operate the main storage reservoir at Toktogul on the Naryn River (a tributary of the Syr Darya) to maximize output of the hydropower plants in the winter. This has created downstream water management problems (see Chapter 3).

## 2.2 Integrated Operation: Potentials and Problems

If the five countries were to integrate their power operations more fully than at present the following benefits would accrue:

- A more efficient use of resources by an "economic dispatch" in which thermal and hydro units are operated in a way that minimizes fuel and other operating costs.
- A sharing of generating capacity in order to reduce the reserve requirements of the individual systems.
- Operation of the hydropower plants to provide system stability, frequency control and rapid response peaking.
- Energy transfers to Kyrgyzstan and Tajikistan in the winter to supplement fuel deliveries.
- Rational use of the hydropower resources to ensure that all reservoir releases flow through the power plants (no spilling of water).
- A return to reservoir release patterns that accord with downstream irrigation and environment needs.

In recent years, the power operations in most of the five countries have been unbundled into separate generation, transmission and distribution companies. An economic dispatch would be of interest to generating companies if the import or export of energy or peaking capacity produces a financial gain. However, at the present time, gas prices in some countries are below market prices and in effect fuel costs are subsidized; this weakens the incentive to import energy.

Therefore, a prerequisite for efficient energy trading is uniform fuel pricing. The main obstacles to a return to an integrated system are differences in the economic and financial status of the five countries. Kazakhstan and Turkmenistan have large foreign exchange earnings from fossil fuel exports that can pay for new thermal generating capacity. Uzbekistan has its own gas resources but the foreign exchange for the purchase of new generating capacity is limited. Kyrgyzstan and Tajikistan have hydropower resources that are seasonal and leave them with large winter energy deficits, and they are short of fossil fuel and the foreign exchange needed for its purchase. There is some scope for Kyrgyzstan and

Tajikistan to trade their hydro energy in the summer for winter fuel and energy, but this option is limited by winter energy shortages in Uzbekistan and South Kazakhstan.

Nevertheless, power exchanges continue to be managed by the UDC for a variety of technical reasons, and also to allow the summer hydropower surplus to be absorbed under the 1998 Framework Agreement on the Use of Water and Energy Resources in the Syr Darya basin. The Naryn Cascade in Kyrgyzstan is consistently operated without spilling water but spilling has recently taken place at the Nurek plant in Tajikistan.

# 3. The Kyrgyzstan Power System

## 3.1 The Present Situation

The main source of power in Kyrgyzstan is the complex of hydropower plants on the Naryn River, known as “the Naryn Cascade”. The Naryn River is the main tributary of the Syr Darya and accounts for 30 % of its total runoff (see Figure 3). The Naryn Cascade (Figure 4) has an installed capacity of 2,870 MW that consists of the Toktogul Reservoir and its 1,200 MW power plant and four downstream run-of-river plants, Kurpsai (800 MW), Tashkumyr (450 MW), Shamaldysai (240 MW), and Uch-Kurgan (180 MW). Annual energy generation is about 10,600 GWh. There are also smaller hydroelectric projects in Kyrgyzstan that have an installed capacity of 70 MW. Annex C shows the basic data of the existing and planned larger hydropower projects.

The thermal energy generated is based on imported fuel for the Bishkek (680 MW) and Osh (50 MW) combined heat and power plants (CHP). These plants are intended to meet the deficit in hydro energy in the winter months and supply steam for the district heating systems of Bishkek and Osh. They are old and suffer from deferred maintenance and replacement; it is reported that the monthly energy that can be produced is no more than 250 GWh compared to 450 GWh in the 1980s.

The energy production of the Naryn Cascade is primarily determined by the outflow of water from the Toktogul Reservoir, and in part by the reservoir level. In the past three years the energy generated by Naryn Cascade was 11,906 GWh (1999), 13,414 GWh (2000) and 12,137 GWh (2001). In these years, inflow to Toktogul was above the long-term average of 12.0 bcm: 25% in 1999, 9% in 2000 and 9% in 2001. In 1999, the volume of water in the Toktogul Reservoir was increased by 0.9 bcm to 14.5 bcm by end of the summer, but in 2000 and 2001 the reservoir was depleted in order to enhance the energy output of the Cascade, and this process was continued in early 2002, with the reservoir being depleted to a volume of less than 8 bcm. The reservoir recovered in the summer of 2002 due to ample inflow, and also reduced releases at the request of the downstream riparians.

## 3.2 Power Operations in Relation to Water Management

One of the main transboundary water and energy issues in Central Asia is the operation of the Toktogul Reservoir in Kyrgyzstan, in the upstream reaches of the Syr Darya basin. Before 1991, when the Syr Darya was operated as an integrated water and power system, the summer releases from Toktogul averaged 8.1 bcm, or 71 percent of the inflow.

There were two reasons for the pre-1991 operating regime. First, was the desire to hold as much water as possible in the reservoir during the winter as a reserve against a low summer inflow. Second, was the need to avoid high winter flows into the Lower Syr Darya when its capacity is restricted by ice formations. Under this operating regime, the winter fuel needs of Kyrgyzstan’s 680 MW of combined heat and power (CHP) plants were supplied by the other republics. In addition energy was transmitted to the Kyrgyzstan through the CAR transmission grid when necessary.

Since independence in 1991, the energy demand patterns of Kyrgyzstan have changed drastically. At the same time, the fuel supply arrangements under the Soviet system were disrupted. Due to fuel shortages the output of the CHP plants was halved, giving rise to increased electric power demand by the population for heating, hot water supply and cooking, stimulated by very low tariffs. To meet the high winter demand for electricity, the operation mode of the Toktogul Reservoir was switched from irrigation to electricity generation, which requires major water releases during winter when power demand is highest. As a result, the winter releases from the reservoir increased from average 2.7 bcm before 1991 to average 7.2 bcm since 1991 (or from 24% of average reservoir inflow before 1991 to 56% of average inflow after 1991).

The sharp increase in winter releases has caused a major environmental impact. Winter inflows to the Chardara Reservoir in Kazakhstan have risen by 30%. But the Lower Syr Darya does not have enough capacity in the winter to transport surplus flows to the Aral Sea; in part this is because of the poor condition of the structures on the river, numerous man-made obstacles, and also the formation of ice jams. In the 1980s, there was only one spill from Chardara into the nearby Arnasay Depression in Uzbekistan, but since 1992, annual spills have accumulated 30 bcm in the Depression. This has damaged land and infrastructure in Uzbekistan and deprived the Syr Darya Delta and the Northern Aral Sea of much-needed water.

The corresponding reduction in summer releases from the Toktogul Reservoir contributed to considerable water stress in Uzbekistan and reduction of the irrigated area in Kazakhstan. Since 1991, the summer releases from Toktogul Reservoir have averaged 6.0 bcm, only 46% of the inflow. The impact of the decline in summer releases on agriculture have been mitigated to some extent because farmers have switched some of their land from summer crops to winter wheat (planted in October and harvested in May/June). However, this change in the cropping pattern is believed to be mainly for economic reasons rather than a water shortage.

To address these problems, in the first half of the 1990's, the Syr Darya basin countries entered into a number of ad hoc annual agreements on water/energy exchanges between the upstream and downstream countries in the Syr Darya basin. In 1997, the Heads of States sought to place these agreements on a more formal footing. USAID/CAR provided technical assistance to high level ministerial delegations at various meetings and roundtables that led to the March 17, 1998 Framework Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin. Tajikistan became a party to this Agreement on June 19, 1998.

The main articles of the agreement provide for:

- Annual agreement on the operation of reservoirs of the Naryn-Syr Darya Cascade, the production of electricity, and the compensation for energy losses.
- The transfer of energy, in excess of the needs of Kyrgyzstan, in equal amounts to Uzbekistan and Kazakhstan.
- Compensation in equivalent amounts of energy resources, such as coal, gas, electricity, and fuel oil, or in monetary terms as agreed upon for annual and multi -year storage in the reservoirs.

The Agreement has a five-year validity that is automatically renewed unless any of the parties object. It serves as a basis for preparation of the annual bilateral and multilateral agreements on the use of water and energy resources of the Naryn-Syr Darya cascade of water reservoirs.

In 1998, high tributary flows greatly reduced the water demand in the Syr Darya basin and Toktogul releases were held to 3.8 bcm in the summer by mutual agreement. But, since then, the summer release has been close to 6 bcm. Fuel has been delivered to Kyrgyzstan as required, albeit with occasional delays. Data for 2001 shows that the deliveries for the winter of 2001/2002 were in line with agreements reached in mid-2001. Nevertheless, there is still a shortage of fuel for winter electricity generation in the Kyrgyz CHP plants; downstream countries still report irrigation water shortages; and losses in the Arnasay depression remain high.

To balance its shortage of fuel for winter energy generation, Kyrgyzstan has had to increase reservoir releases and power generation from Toktogul in the winter. In recent years, annual releases from the reservoir have substantially exceeded annual inflows, despite substantially higher than average inflows of water into the reservoir.

### 3.3 Load Forecast

Since independence in 1991, the demand patterns and the fuel-energy balance of Kyrgyzstan have changed drastically. Due to complications in intergovernmental relations and account settlements, introduction of national currencies, rising prices of oil, coal, natural gas and higher transportation costs, the supply of fuel to Kyrgyzstan was reduced. The loss of foreign markets for most of Kyrgyzstan's exports caused a sharp drop in the electricity demand of the industrial and agriculture sectors.

At the same time, the fuel supply arrangements under the Soviet system were disrupted and Kyrgyzstan experienced a shortage of fuel for the CHP plants. The decline in heat output led to a sharp rise in the use of electricity for domestic purposes. The drop in demands for industry and agriculture was more than offset by a rapid growth in residential demand that was further stimulated by very low tariffs. Since electricity losses are higher in the residential sector this also contributed to a four-fold increase in losses.

The dramatic redistribution of demand among consumer groups, and the corresponding growth in losses within the last ten years is illustrated in Table 3.1. This table is based on data provided by the State Energy Agency and shows a very high level of losses of 42% of gross consumption (generation plus imports minus exports).

**Table 3.1 Demand by Consumer Group.**

| Consumer Group | Demand (GWh) | | | |
|---|---|---|---|---|
| | 1991 | 1999 | 2000 | 2001 |
| Industry | 3,509 | 1,531 | 1,369 | 1,286 |
| Commercial | 1,178 | 1,262 | 1,365 | 1,551 |
| Agriculture | 1,986 | 656 | 586 | 508 |
| Residential | 1,455 | 3,802 | 4,455 | 3,179 |
| Losses | 1,064 | 3,740 | 3,839 | 4,806 |
| Gross Consumption | 9,192 | 11,222 | 11,876 | 11,572 |

The growth in gross consumption in recent years is largely due to the higher level of technical losses. Annex A shows monthly generation, imports and exports for the years 1999, 2000 and 2001, from which it can be seen that the January energy demand is more than three times the demand in the summer months, and percentage losses in the winter are much higher than in the summer.

As a result, the system load factor is very high in the winter months (over 80%); this is typical of a system where demand is limited by the supply. Tariffs are low, less than 1US cent per kWh, and the rate of collection is poor. The resulting low revenue and Kyrgyzstan's low foreign exchange earnings limit the ability to purchase fuel to cover the fuel requirements needed in addition to what Kyrgyzstan imports from the downstream countries through the implementation of the 1998 Agreement (see previous section).

Kyrgyzstan depends for most of its energy on the seasonal output of its hydropower plants, which varies from month to month according to releases form the Toktogul Reservoir. Therefore a load forecast has to estimate the monthly as well as the annual demands. Also, the effect of loss-reduction programs (as recommended in the USAID TWEP report "Support to Electricity Loss Reduction in Kyrgyzstan" dated 23 September, 2002 by PA Consulting) has to be taken into account. Other factors that would tend to limit load growth are the impacts of higher tariffs and the constrained supply until new capacity is added to the Kyrgyzstan system.

In 2000, the electrical energy that was paid for by end-users was 7,800 GWh. The losses of 3,800 GWh in that year can be assumed to include 50% (1,900 GWh) of energy that was used but not paid for. Thus, the actual end use was possibly about 9,700 GWh. For the purposes of this report the demand by 2010 and 2015 assumes 1.3% annual growth in end use, technical losses of 18%, and a winter/summer ratio declining from 3.2 to 2.0. System load factors are assumed to be 65% in the winter and 55% in the summer. From now to 2005, the effect of loss reduction and higher tariffs will be small and it is assumed that gross consumption grows at 1.0 % annually. These assumptions lead to the load forecasts presented in Annex B. It should be noted that the findings of this report are not particularly sensitive to the load forecasts.

### 3.4 Alternative Toktogul Operating Regimes

The hydro energy produced by the Naryn Cascade in 1999, 2000, and 2001 was much higher than the long-term average. In those years the outflows were 13.1 bcm (1999), 14.8 bcm (2000) and 13.8 bcm (2001). Over the long term, the outflow should not normally exceed the average inflow of 12.0 bcm and this would produce on average about 10,700 GWh compared to the average for the last three years of 12,500 GWh. Therefore, the objectives of the operation studies are to examine, under conditions of average annual reservoir inflow, the effect of different operating regimes on (a) annual and seasonal energy shortages and the need for fuel and energy imports and (b) the peak monthly winter energy deficit. There are basically three operating regimes that could be adopted at Toktogul Reservoir:

- T65. This regime is similar to the pre-1990 situation, when the summer outflow from Toktogul was about 65 % of the annual inflow (7.8 bcm).
- T55. This regime is more or less similar to the present situation when a summer outflow of 6.5 bcm is maintained (this is 55 % of the average annual inflow).
- T22. This regime would concentrate most of the outflow in the winter months so that the summer outflow is only 2.7 bcm (this is 22 % of the average annual inflow).

A monthly operation study was run for the Naryn Cascade for an average flow year (12.0 bcm) for each of these regimes. It is assumed that 250 GWh is available in any month from the existing thermal plants. Demands are for the year 2005 (5 % higher than the Year 2000 demand). The calculations and results of the operation study are presented in Annex D and summarized in Table 3.2 below.

**Table 3.2 Comparison of Toktogul Operating Regimes.**

| **Results Operating Regimes** | **Regime (all figures in GWh)** | | |
|---|---|---|---|
| | **T65** | **T55** | **T22** |
| Annual Energy Demand | 12,484 | 12,484 | 12,484 |
| Hydro Energy Generation | 11,012 | 10,983 | 10,732 |
| Sum of Monthly Surpluses | 3,559 | 2,355 | 0 |
| Sum of Monthly Energy Deficits: | 5,031 | 3,856 | 1,804 |
| Supplied by Existing Thermal Plants | 1,500 | 1,500 | 1,760 |
| Supplied by Energy Imports | 3,531 | 2,356 | 43 |
| Net Annual Energy Deficit | 1,472 | 1,501 | 1,804 |
| Maximum Monthly Energy Import | 784 | 666 | 43 |

The conclusions to be drawn from this analysis are as follows:

- The high level of hydropower generation since 1999 is not sustainable. It has (a) exaggerated the size of the summer energy surplus from the Naryn Cascade and (b) disguised the size of the overall energy deficit in the Kyrgyzstan Power System.
- The Kyrgyzstan Power System will face large and growing energy deficits in the years before Kambarata 1 might be in service. Kambarata 2 would not significantly relieve the winter energy shortage because it produces only 290 GWh in the winter. Summer production of about 970 GWh would increase the hydro surplus that can be traded for winter fuel and thereby reduce the annual surplus.
- None of the operating regimes, even Regime T22, the most extreme "power oriented," eliminates the need for either large imports of fuel for the existing thermal power plants or imports of electrical energy.
- The annual hydro energy generated differs little between the three regimes. The high summer flow regimes (T65 and T55) tend to operate at higher heads during the high flow months and, therefore, produce slightly more annual energy than Regime T22. In other words, the "irrigation regimes" produce more annual energy than a "power regime".
- The annual energy deficit does not differ greatly between the three regimes, but the seasonal distribution of deficits and surpluses are quite different. In Regime T22, there are no months with a hydro surplus because of the concentration of reservoir releases in the winter, and most of the winter deficit is met by running the existing thermal plants. In Regimes T65 and T55, there are large summer surpluses and most of the winter deficit is met from imports of energy.

The very low reservoir release in the main growing season of Regime T22 would be unacceptable to the downstream riparians and remove their incentives to deliver winter fuel and energy through implementation of the 1998 Agreement. One of the main problems created by the post-Soviet operation at Toktogul has been environmental; namely the large unusable winter releases spilled into the Arnasay Depression Regime. T65 has an advantage over Regime T55 in that it might be more effective in reducing spills into the Arnasay Depression and increasing the flow into the Northern Aral Sea. An ongoing World Bank-financed project is designed to remove some of the structural obstacles to winter flow in the Lower Syr Darya. The outcome of this project will have a bearing on the choice of operating regime for Toktogul.

# 4. THE KAMBARATA 1 AND 2 PROJECTS

## 4.1 Existing Studies and Data

In 1993, Harza Engineering Company, under contract to USAID, prepared a report entitled "Evaluation of the Hydroelectric Development Program of Kyrgyzstan". Kambarata 1 and Kambarata 2 and other smaller hydroelectric projects were reviewed using data from investigations and plans made in the Soviet era.

Kambarata 1 and Kambarata 2 are on the Naryn River (Figure 2) and are the largest projects listed in the Harza Report. While many sites for hydropower development have been identified in Kyrgyzstan, their winter energy production is very low. Some small-scale hydropower projects have been built and others might be developed to serve local communities.

For Kambarata 1, two types of dam were considered: an arch dam and a rock-fill dam. The rock-fill alternative would employ a method pioneered by Soviet engineers in which the sides of the valley are blasted to form a dam, termed a "blast-fill dam". For Kambarata 2, two alternatives were considered, a rock-fill dam and blast-fill dam. The Harza report has drawings, construction quantities, and unit prices for both alternatives.

The main features of the two projects are as follows:

| | Kambarata 1 | Kambarata 2 |
|---|---|---|
| Height of dam | 245 m | 60 m |
| Gross Reservoir Volume | 4,500 mcm | 70 mcm |
| Dead Storage Volume | 380 mcm | 62 mcm |
| Average Annual Reservoir Inflow | 10,463 mcm | approx. same as Kambarata 1 |
| Maximum Head | 233 m | 50 m |
| Minimum Head | 106 m | 47 m |
| Installed Capacity | 1200/1600 MW | 400/600 MW |

## 4.2 Dam Alternatives Considered

For this Report, the arch dam alternative (Figures 5 and 6) was used as a basis for the Kambarata 1 cost estimate since there are no blast-fill dams that have been subject to international competitive bidding. Harza proposed an installed capacity of 1,700 MW for the arch dam alternative. The intent was apparently to export power to other Asian countries outside of the CAR (a 706 km transmission line was proposed). With Kambarata 1 and Kambarata 2 on line, Kyrgyzstan would have a surplus of peaking capacity and would be in a position to export power within the CAR.

However, it should be noted that the export of peaking capacity involves some export of energy that will still be in short supply in the winter (for example, export of 1,000 MW for three hours per day requires 90 GWh in one month). For the needs of Kyrgyzstan alone, an installed capacity of 1,200 MW has been adopted for Kambarata 1 since this would be sufficient to exploit the full energy potential of the site. It would be a simple matter to install additional units in the future, and the cost estimate covers the works needed to permit such expansion.

The rock-fill alternative (Figures 7 and 8) was used for the Kambarata 2 estimate. Harza proposed an installed capacity of 350 MW. For Kambarata 2 as a single project this study adopts a capacity of 400 MW (2X200 MW) in the absence of Kambarata 1. For Kambarata 2, with Kambarata 1 in place, the winter energy generation (but not the annual energy generation) would be higher and therefore a third 200 MW unit could be installed to bring the capacity to 600 MW.

# 5. COST ESTIMATES

## 5.1 Kambarata 1

The Ertan Hydroelectric Project in China, completed in 2000, was used as a reference for unit prices (quoted by the lowest bidders) to be applied to the Harza quantities. Ertan has a 240 m high arch dam and an installed capacity of 3,300 MW. Details of the cost estimate are given in Annex F.

The main changes from the Harza estimate are:

- An installed capacity of 1,200 MW (see above) instead of the Harza plan for 1,700 MW. The civil works for the 1,700 MW are retained so that the estimate covers future expansion.
- A cost/kW for generators and turbines of US$ 120 based on the Ertan costs.
- A 20 % contingency is applied only to the civil works.
- Additions to the Harza estimate included higher costs for the preparatory works and mobilization; an item for river diversion and care of water.
- A 260 km transmission line to connect Kambarata 1 to Northern Kyrgyzstan and Kazakhstan instead of a 706 km line.

The result is a cost for Kambarata 1, of US$ 970 million in 1990 prices. It then becomes necessary to convert this 1990 price to constant 2002 US dollars. An accepted World Bank method to convert past costs to constant dollars is to apply the Index of the Value of Manufactured Export, commonly referred to as the MUV Index.

The following table shows figures from May 2002 of the Worlds Bank's Economic Policy and Prospects Group (the Index base level is 2001):

| **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 104.2 | 106.3 | 110.4 | 111.2 | 115.2 | 122.0 | 116.0 | 107.9 | 103.8 | 103.5 | 101.5 | 100.0 |

The estimated figure for 2002 is 99.5. Thus, for practical purposes the 1990 cost is essentially the same when converted to 2002 constant dollars. However the situation at Ertan was more favorable than at Kambarata 1. Ertan was well served by a railway, and the Chinese economy could provide cement, steel etc. at competitive prices. Thus, the 2002 cost has been raised by 20% to allow for this and it becomes US$ 1,163 million.

## 5.2 Kambarata 2

The Harza unit prices were used except where the Ertan prices were considered more appropriate. Details of the cost estimate are given in Annex F. The main changes from the Harza estimate are:

- A cost/kW for generators, turbines transformers of US$ 130 (based on a lower head than Kambarata 1).

- An initial installed capacity of 400 MW, increased to 600 MW when Kambarata 2 is operated in conjunction with Kambarata 1.
- A 20% contingency is applied only to the civil works.
- Additions to the Harza estimate included an item for river diversion and care of water.

Some work has already been done at the site, including the construction of diversion tunnels, but no allowance is made for this in the cost estimate. The cost in 1990 dollars is US$ 227 million. After the same adjustments as for Kambarata 1, the cost is US$ 280 million.

# 6. BENEFITS TO THE CAR AND KYRGYZSTAN ENERGY SYSTEMS

## 6.1 Results of System Operation Studies

The purpose of the system operation studies is to estimate monthly and annual energy produced by the Kambarata Projects along with Toktogul and the other hydropower projects in the Naryn Cascade. This output is then compared to monthly system demands in order to arrive at deficits and surpluses in monthly energy and power generation after allowance for the output of existing thermal power plants. Details of the system operation studies are given in Annex E.

These power and energy balances are carried out for the years 2010, the earliest at which Kambarata 1 could be on line, and 2015, possibly several years after Kambarata 1 is in service. For Kambarata 2, as a stand-alone project, its in-service date is left indeterminate since neighboring CAR countries could absorb its peaking capacity as soon as it could be built. Without Kambarata 1, Kambarata 2 is mainly a summer energy producer and would do little to solve Kyrgyzstan's winter energy problem.

The annual inflow to Kambarata 1 is about 88% of the inflow to the Toktogul Reservoir. Stream flow data and the characteristics of reservoirs and power plants are taken from the Soviet records.

The studies are made for Kambarata 1 with Kambarata 2, and also for Kambarata 2 alone. In all cases they are combined with the existing Naryn Cascade. The live storage capacity of Kambarata 1 is 4.12 bcm. With that capacity the project could be operated without spilling water past the powerhouse. In other words the entire flow of the Naryn River at the site would be fully controlled and regulated. Although the operation of Kambarata 1 would modify the seasonal pattern of inflow to the Toktogul Reservoir it would not in any way limit the operators of Toktogul Reservoir in their choice of monthly releases patterns. This is because the live storage of the Toktogul Reservoir is so large, almost equal to the average annual inflow, that it allows a high degree of regulation. All studies are done for an average water year.

The Kambarata 1 reservoir is operated to meet certain targets for the reservoir content at the end of each month. A rule curve defines the end-of-month reservoir content. For example, if the figure for January is 0.65, the end-of-month content is 0.65*4,500 million cubic meters (mcm). Two rule curves were adopted in the alternatives examined. Rule Curve RW is designed to maximize the winter energy production; this requires drawing on the live storage of the reservoir of 4.12 bcm in the winter months. Rule Curve RA aims to maximize the annual energy production by keeping the reservoir at its maximum level most of the year except when (a) it is drawn down a small amount in the winter months to improve the performance of Kambarata 2 and (b) held to 90% of reservoir capacity in May and June for flood control purposes. A manual adjustment of the monthly releases between October and March is made to produce a more or less even amount of monthly energy in the winter months. In all the options studied the Toktogul reservoir is operated to provide a specified release in the summer.

The storage at Kambarata 2 is too small to provide seasonal regulation, but it can provide daily regulation. Without Kambarata 1, the energy production of Kambarata 2 in the winter months is so low that it could run at full capacity for only two to three hours. With the

Kambarata 1 operating upstream, the winter energy is increased and its capacity as a peaking plant can be raised from 400 MW to 600 MW. A separate study is made of Kambarata 2 as a stand-alone peaking project. The results obtained are summarized in Table 6.1, and details are presented in Annex E. Alternatives A and B with a summer outflow of 7.8 bcm at Toktogul show the effects of rule curves for maximizing annual energy or winter energy. Alternatives C and D with a summer outflow of 6.5 bcm also show the effects of the two rule curves.

**Table 6.1 Comparison of Alternatives for the Year 2015**

| Results | Alternative (All figures in GWh except where noted) | | | |
|---|---|---|---|---|
| | Alternative A | Alternative B | Alternative C | Alternative D |
| Toktogul Regime | T65 | T65 | T55 | T55 |
| Summer Outflow from Toktogul | 7.8 bcm | 7.8 bcm | 6.5 bcm | 6.5 bcm |
| Rule Curve | RW | RA | RW | RA |
| Energy Demand | 13,893 | 13,893 | 13,893 | 13,893 |
| Hydro Energy Generation | 16,893 | 17,956 | 16,879 | 17,946 |
| - Kambarata #1 | 4,624 | 5,737 | 4,624 | 5,737 |
| - Kambarata #2 | 1,256 | 1,256 | 1,256 | 1,256 |
| - Cascade | 11,014 | 10,963 | 11,000 | 10,954 |
| Summer Hydro Surplus | 4,334 | 7,077 | 3,196 | 5,941 |
| Winter Demand minus Hydro: | 1,334 | 3,014 | 209 | 1,888 |
| - Supplied from Existing Thermal | 1,168 | 1,500 | 209 | 1,469 |
| - Supplied by Energy Imports | 166 | 1,514 | 0 | 538 |
| Max. Monthly Import | 121 | 429 | 0 | 214 |
| Annual Energy Surplus | 3,000 | 4,063 | 2,986 | 4,053 |
| Summer Peak Surplus | 2,862 MW | 2,953 MW | 2,853 MW | 2,954 MW |
| Winter Peak Surplus | 894 MW | 1,196 MW | 871 MW | 1,173 MW |

The positive feature of Alternative C in comparison with the other alternatives is the lowest winter demand on the existing thermal plants. This alternative is adopted as a basis for the discussions and economic analyses that follow in this report; it involves a summer release from Toktogul of 6.5 bcm, and a rule curve that maximizes winter energy. The downstream riparians might favor a somewhat higher summer release from Toktogul in most years; this could be accommodated without a major change in the monthly pattern of the energy deficit.

## 6.2 Contribution to the Kyrgyzstan Energy System

The basic problem with the Kyrgyzstan power system is that the Naryn Cascade and the existing thermal plants cannot meet winter energy demand. By the Year 2005, with no additional capacity in service and average river flows, Kyrgyzstan will have an annual energy deficit of about 1,500 GWh, composed of a winter deficit of 3,900 GWh and a summer surplus of 2,500 GWh (Table 3.2). This assumes the existing thermal plants will be available in all months to produce 250 GWh. Under present conditions, the peak monthly deficit will be 760 GWh, which is equivalent to the continuous output of a 1,000 MW power plant. The energy deficits have not reached these levels in the past because of unusually high inflows coupled with unsustainable withdrawals from the Toktogul Reservoir.

At present, Kyrgyzstan imports fuel in the winter and surplus hydro energy is exported under the terms of the 1998 Framework Agreement. Unfortunately, this alone is not enough to meet the winter deficits. A large block of winter energy will soon have to be imported from Uzbekistan or Kazakhstan or both. Thus, the importation of winter energy could conceivably be financed by the sale of the summer hydro surplus. Kyrgyzstan will soon face more severe shortages than have been experienced in recent years. Hydro energy generation has been 30% above sustainable levels. Table 3.2 shows that the large deficits far exceed Kyrgyzstan's existing thermal capacity (that relies on imported fuel). Rehabilitation of existing thermal plants is urgently needed.

Of the two upstream hydropower projects, Kambarata 2 could come on line at the earliest in 2007. But this project's annual output of only 1,260 GWh (290 GWh in the winter) would not help significantly to relieve the winter energy deficit. By 2015, with Kambarata 1 and Kambarata 2 in the system, Kyrgyzstan would have an annual energy surplus, mostly in the summer months of about 3,000 GWh and considerable excess peaking capacity, and the winter energy deficit would be eliminated.

Thus, the main elements of a power development plan for Kyrgyzstan are:

- Rehabilitation of the existing thermal power plants at Bishkek and Osh to restore their capacity to 680 MW and 50 MW respectively.
- Continued imports of fuel and energy in return for exports of the summer hydro surplus under the 1998 Framework Agreement.
- Completion of the Kambarata 1 project and Kambarata 2 Projects.
- An aggressive program to reduce losses from the present level of over 40% to no more than 18% (losses of 18% are assumed in the operation studies described in Chapter 6).
- A program to encourage consumers to move from electric heating to gas heating, and where possible coal heating.
- Investigation of Kyrgyzstan's coal resources as a base for thermal power (in the 1980's, over one million tons of coal was mined in the Kyrgyzstan, but production is now down to 100,000 tons).

### 6.3 Contribution to the Central Asian Power System

As noted above, Kambarata 2, without Kambarata operating upstream would produce most of its 1,260 GWh energy in the summer, and this would be of value to trade for winter energy. It could also be of interest to South Kazakhstan or Uzbekistan as a peaking plant with a capacity of 400 MW as a stand-alone project, or with 600 MW after completion of Kambarata 1. The project might be a possibility for private financing.

If Kambarata 1 and Kambarata 2 were both in service (installed capacity of 1,800 MW) there would be capacity in excess of Kyrgyzstan's needs of 1,000 MW in the winter and 2,800 MW in the summer (this includes the surplus summer peaking capacity of the Cascade), and a hydro energy surplus in the summer months of 3,000 GWh.  Hydropower plants are also valuable components of a mixed thermal-hydro system because they respond quickly to sudden load changes and provide frequency regulation and system stability.

# 7. ECONOMIC FEASIBILITY

## 7.1 Method of Analysis

One way to test the competitiveness of a hydropower project is to compare two alternative system expansion plans. The project in question is included in one plan and in the second plan its place is taken by the least-cost alternative. The operation of the two plans is then simulated on a monthly basis for about 30 years, and all capital and recurrent costs are then discounted to the present at an appropriate discount rate. The plan with the lowest present value is the preferred solution.

However, such a method calls for more data than is currently available for the Kyrgyzstan power system and, therefore, a direct comparison of Kambarata 1 with a thermal power alternative has been adopted. Possible thermal alternatives are a coal-fired steam plant fuelled by imported coal or coal from Kyrgyzstan's Kara Keche mine, or a gas-fired plant fuelled by imported gas. There are no current estimates of the coal-fired option and it is unlikely to be less costly in capital or operating costs than a gas-fired plant. Therefore, the least-cost alternative adopted is a gas-fired combined cycle plant. The analysis includes:

- A comparison with the least-cost alternative that produces an equalizing discount rate (EDR). This is the rate that equalizes the present value of the cost streams of the hydro project and the least-cost alternative. A hydro project has a high capital cost and low operating cost, whereas the reverse is true for a thermal power project. A low discount rate favors a hydro project, but its justification must rest on an acceptable discount rate. In general this is taken as the opportunity cost of capital that is often assumed to be in the range of 10-12%.
- Calculation of the economic rate of return (ERR), in which the benefit stream is the average annual energy production (after losses and station use) priced at the higher of the retail tariff or the consumers' willingness to pay.

## 7.2 Kambarata 1

Kambarata 1 is compared to a 1,200 MW gas-fired combined cycle with a capital cost of US$ 750/kw (including additional pipeline capacity) and a fuel cost of 2 cents per kWh (based on the current Uzbekistan export price of US$ 54 per 1,000 cubic meters). With these assumptions, the EDR is 11%. For the economic analysis, a willingness to pay of 6 cents/kWh and losses of 20% were assumed. This gives an ERR of 12%.

It can be concluded from this analysis that Kambarata 1 is competitive with the least-cost thermal alternative. It also has the considerable advantage that it avoids the use of imported fuel. If the scarcity value of foreign exchange were taken into account, Kambarata 1 would become more attractive.

Even though operation of the power systems of the CAR countries is less integrated than in the Soviet times, hydroelectric plants still have a role in providing system stability. As the CAR systems grow, the role of the Naryn Cascade and Kambarata 1 will become more important. However, the benefits of Kambarata 1 in terms of frequency control and spinning reserve have not at this stage, been quantified.

## 7.3 Kambarata 2

Kambarata 2 would operate as a peaking plant. If it were built and operated in the absence of Kambarata 1, it would be a 400 MW plant, with provision for future installation of a third 200 MW unit on the completion of Kambarata 1. Kambarata 2 has been compared to a gas turbine, commonly installed for short-duration peaking, with a capital cost of US$ 400/kw and a fuel cost of 2.4 cents per kWh. With these assumptions, the EDR is 15%. With the same assumptions as Kambarata 1, the ERR is 13%. It can be concluded from this analysis that Kambarata 2 is competitive with the least-cost thermal alternative.

# 8. WATER MANAGEMENT, SOCIAL, AND ENVIRONMENTAL IMPACTS

The basic problem with the Kyrgyzstan power system is that the hydropower projects of the Naryn Cascade (the 1,200 MW Toktogul dam and reservoir, and 1,670 MW of run-of-river hydropower plants), produce most of their energy in the summer, whereas the peak energy demand is in the winter months. The result is a high winter demand on the existing thermal power plants that requires large imports of fuel and energy. Consequently, the operators of Toktogul aim to maximize reservoir releases and energy production in the winter and minimize reservoir release to the downstream countries in the summer.

To address this energy/irrigation conflict, the Syr Darya basin countries entered into the March 17, 1998 Framework Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin. Tajikistan became a party to this Agreement on June 19, 1998. This provides for winter fuel to be delivered to Kyrgyzstan in return for sales of hydro energy in the summer months.

The sharp increase in winter releases in the 1990s has also caused a major environmental impact. Winter inflows to the Chardara Reservoir in Kazakhstan have risen by 30%. But the Lower Syr Darya does not have enough capacity in the winter to transport surplus flows to the Aral Sea; in part this is because of the poor condition of the structures on the river, numerous man-made obstacles, and also the formation of ice jams. In the 1980s, there was only one spill from Chardara into the nearby Arnasay Depression in Uzbekistan, but since 1992, annual spills have accumulated 30 bcm in the Depression. This has damaged land and infrastructure in Uzbekistan and deprived the Syr Darya Delta and the Northern Aral Sea of much-needed water.

This report looked at the effect on Kyrgyzstan's winter energy shortage of different operating regimes for the Toktogul Reservoir in the years before Kambarata 1 would be in service. It was found that none of the operating regimes, even the most extreme “power oriented regime”, eliminates the need for large imports of fuel and energy under present conditions. By the Year 2005, with no additional capacity in service and average river flows, Kyrgyzstan will have an annual energy deficit of about 1,500 GWh, composed of a winter deficit of 3,900 GWh and a summer surplus of 2,400 GWh. The energy deficits have not reached these levels in the past because of unusually high reservoir inflows coupled with unsustainable withdrawals from the Toktogul Reservoir. Hydro energy generation has been 30% above sustainable levels. It is clear, therefore, that Kyrgyzstan’s needs for imports of fuel and energy will continue to grow until new capacity is installed.

The addition of Kambarata 1 will eliminate the winter deficits and thereby eliminate the conflict in the operation of the Toktogul Reservoir between the irrigation and environmental needs of the downstream countries and the winter energy needs of Kyrgyzstan. Kambarata 2 would add to Kyrgyzstan’s summer hydro surplus that could be exchanged for fuel imports, but it would not significantly reduce the winter energy deficits.

The adverse social and environmental impacts of Kambarata 1 and Kambarata 2 appear to be quite limited. The reservoirs are reported to have no permanent residents and only a few livestock herdsmen. Nevertheless, a detailed social and environmental study should be carried out.

# 9. NEXT STEPS

A workshop was held in Bishkek on February 25-26, 2003 to seek the comments of Kyrgyzstan power sector officials on the report. This led to useful suggestions on technical issues and a valuable exchange of views on the regional aspects of the two projects. This report reflects the findings of the workshop.

Following discussion of this report with energy sector officials in Kazakhstan, the next steps are likely to be as follows:

- Set up a Working Group of Kyrgyzstan and Kazakhstan experts to oversee the following activities.
- Prepare more detailed feasibility studies for the two projects. These would include an investigation of the possibility of staging Kambarata 1 including an analysis of different configurations of the 500 kV transmission network. The studies would present in more detail the costs and benefits of the projects and their contribution to the power systems of Kyrgyzstan and its neighbors, and their impact on water management.
- Investigate possible financing and institutional arrangements for further development of the projects.

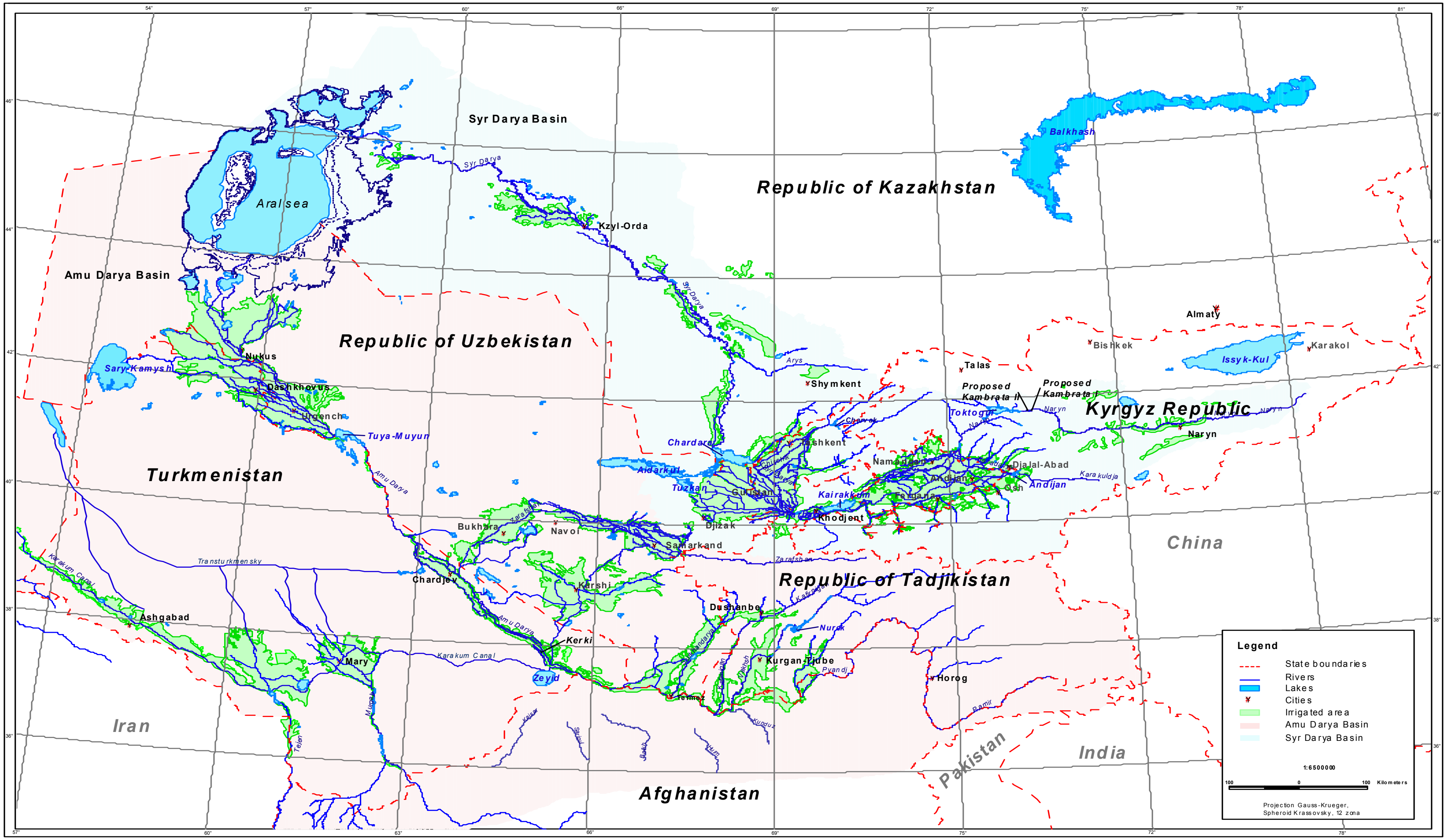
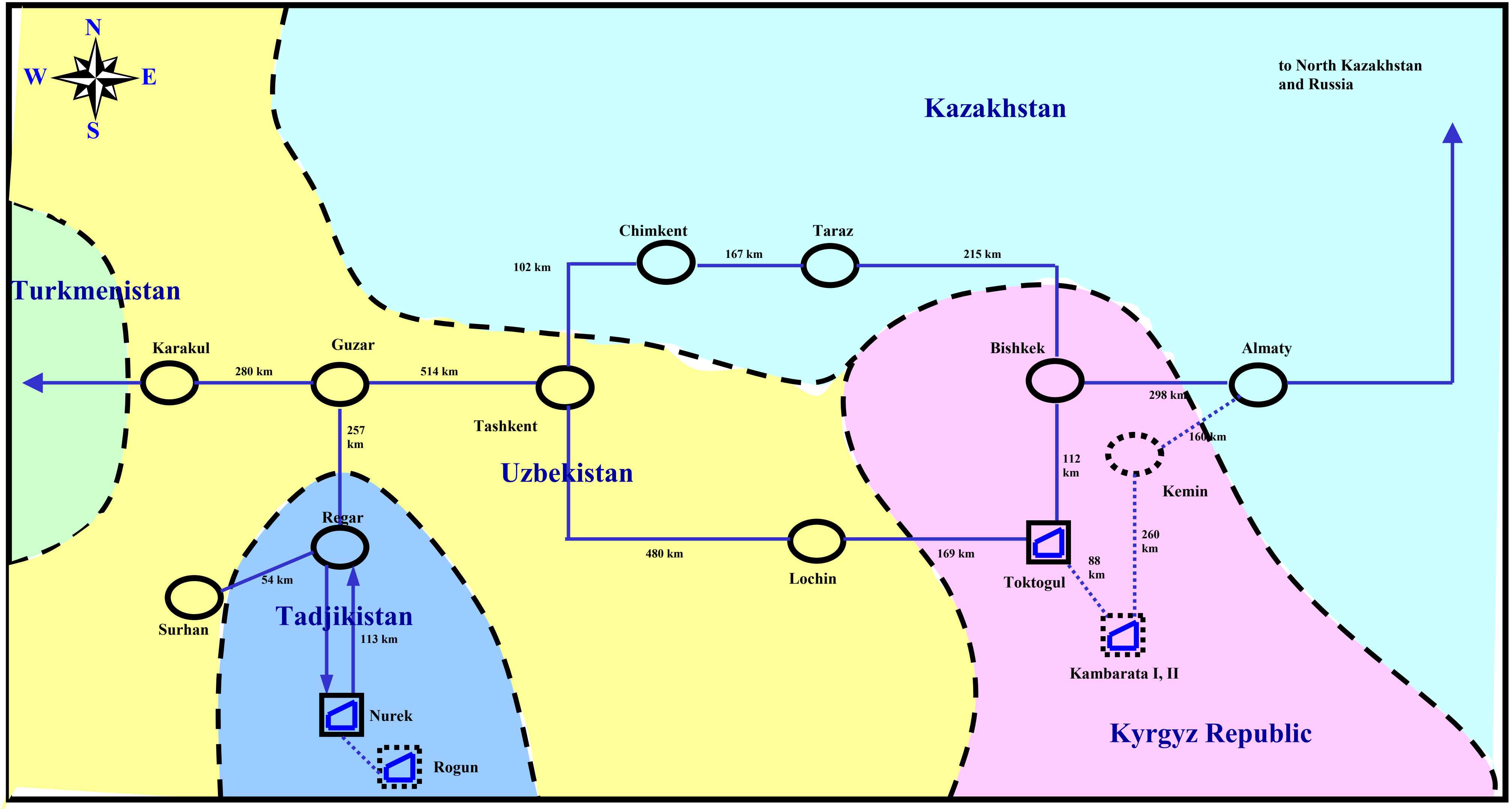



**Figure 1. Aral Sea Basin**




500 kV Substation
Hydro Power Plant
500 kV Line
Border
Planned 500 kV Substation
Planned Hydro Power Plant
Planned 500 kV Line

**Figure 2. The CAPS Grid**

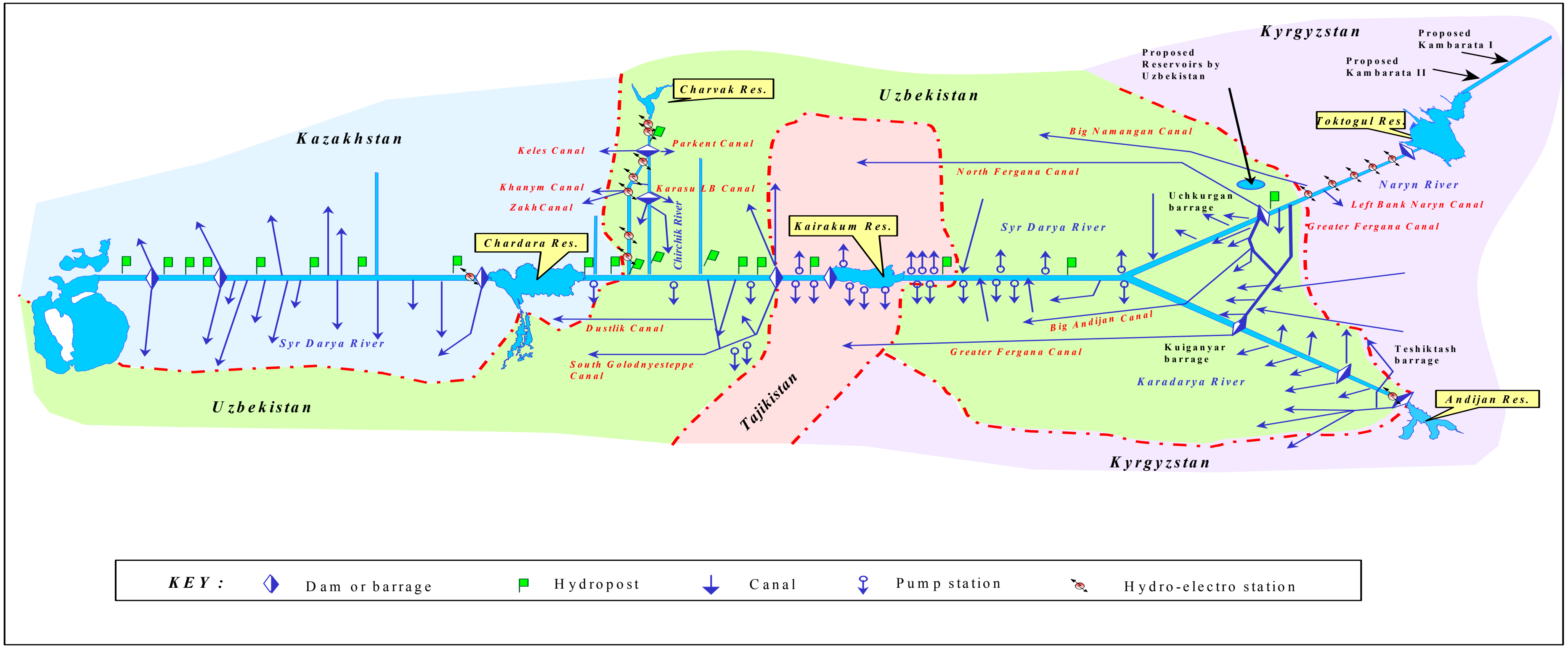



**Figure 3. Water and Hydropower Facilities of the Syr Darya Basin**

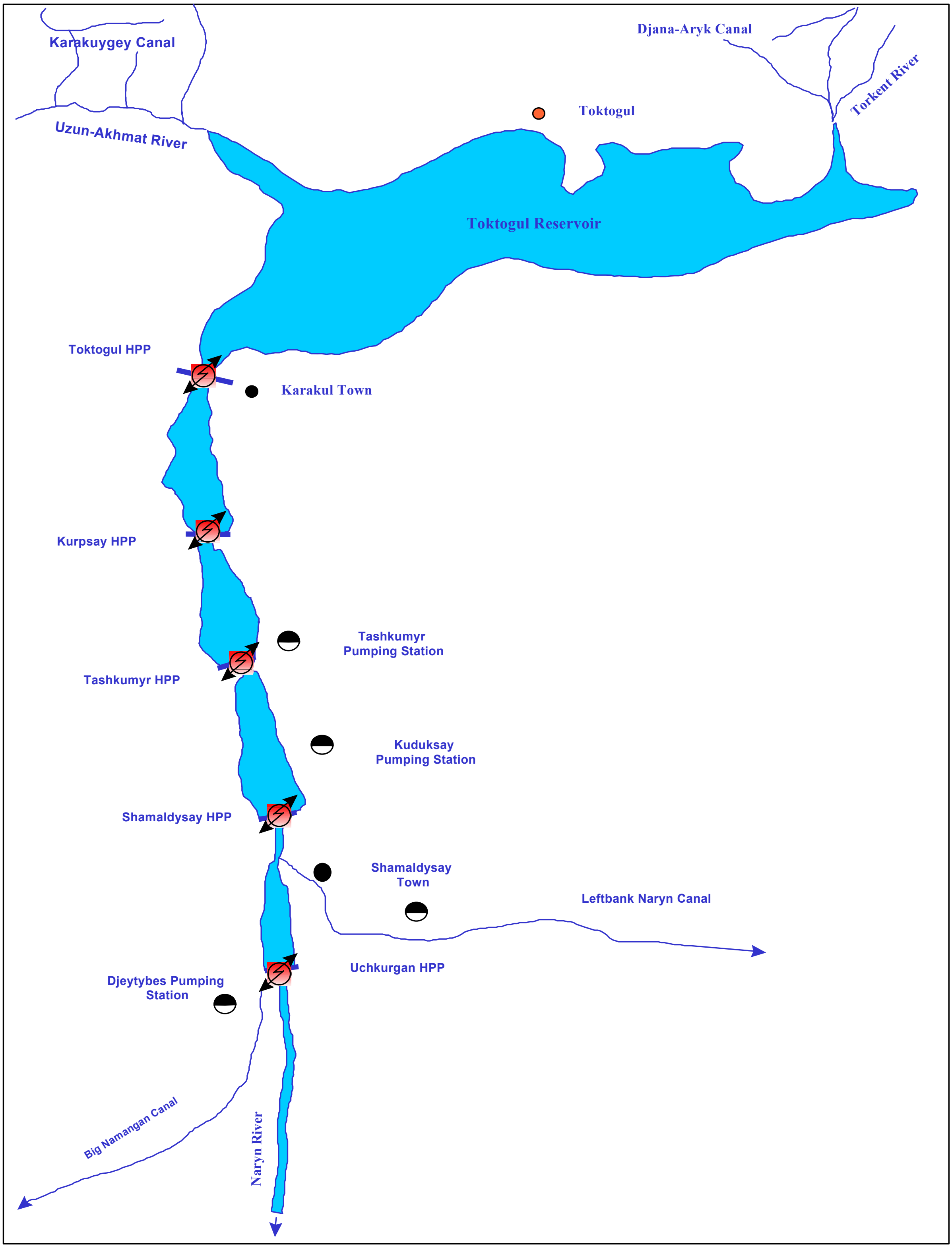



**Figure 4. The Naryn Cascade**

# ANNEX A: KYRGYZSTAN POWER SYSTEM-GENERATION, IMPORTS AND EXPORTS

| YEAR 1999 | Totals | Jan | Feb | March | April | May | June | July | August | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Generation** | **13,119** | **1,641** | **1,327** | **1,400** | **999** | **664** | **662** | **1,093** | **1,021** | **536** | **804** | **1,356** | **1,616** |
| **Thermal** | **982** | **197** | **158** | **157** | **62** | **28** | **15** | **14** | **14** | **28** | **53** | **107** | **150** |
| **Hydro** | **12,138** | **1,444** | **1,169** | **1,243** | **937** | **637** | **647** | **1,079** | **1,008** | **508** | **750** | **1,250** | **1,466** |
| Toktogul | 4,991 | 629 | 493 | 514 | 371 | 198 | 226 | 423 | 425 | 199 | 316 | 554 | 644 |
| Kurpsai | 3,353 | 409 | 333 | 363 | 266 | 187 | 176 | 289 | 270 | 133 | 199 | 334 | 394 |
| Tashkumyr | 1,918 | 210 | 175 | 192 | 149 | 123 | 119 | 184 | 160 | 83 | 116 | 189 | 218 |
| Shamaldysai | 685 | 67 | 56 | 64 | 56 | 46 | 48 | 70 | 61 | 32 | 41 | 61 | 83 |
| UchKurgan | 959 | 110 | 95 | 94 | 82 | 61 | 57 | 85 | 73 | 36 | 57 | 96 | 114 |
| Small Hydro | 54 | 10 | 9 | 7 | 5 | 3 | 2 | 3 | 3 | 6 | 3 | 2 | 1 |
| Small Hydro | 50 | 2 | 2 | 1 | 1 | 6 | 6 | 7 | 7 | 7 | 7 | 4 | 2 |
| Small Hydro | 127 | 7 | 8 | 6 | 7 | 13 | 14 | 19 | 10 | 13 | 11 | 10 | 10 |
| TPBishkek | 918 | 179 | 142 | 145 | 62 | 28 | 15 | 14 | 14 | 28 | 53 | 103 | 136 |
| TP Osh | 64 | 18 | 16 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 15 |
| **Import** | **4** | **0** | **1** | **0** | **0** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** |
| Tajikistan | 185 | 0 | 0 | 0 | 0 | 23 | 58 | 32 | 28 | 43 | 0 | 0 | 2 |
| Uzbekistan | 138 | 0 | 0 | 0 | 0 | 14 | 26 | 27 | 28 | 43 | | | 0 |
| Kazakhstan | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 2 |
| Turkmenistan | 46 | 0 | 0 | 0 | 0 | 9 | 32 | 5 | 0 | 0 | | | 0 |
| | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | | 0 |
| **Export** | **1,999** | **15** | **18** | **72** | **105** | **67** | **196** | **596** | **516** | **62** | **143** | **141** | **69** |
| Uzbekistan | 970 | 2 | 0 | 0 | 0 | 21 | 148 | 413 | 387 | 0 | | 0 | 0 |
| Kazakhstan | 880 | 14 | 12 | 15 | 19 | 46 | 48 | 184 | 128 | 62 | 143 | 141 | 69 |
| Tajikistan | 149 | 0 | 6 | 57 | 86 | 0 | 0 | 0 | 0 | 0 | | | 0 |
| China | 0 | | | | | 0 | 0 | 0 | 0 | 0 | | | |
| Losses in Kazakhstan | 136 | 11 | 8 | 10 | 13 | 12 | 9 | 0 | 5 | 8 | 13 | 20 | 27 |
| **Gross Consumption** | **11,222** | **1,614** | **1,302** | **1,318** | **882** | **609** | **516** | **529** | **529** | **509** | **697** | **1,196** | **1,522** |
| | 0 | | | | | | | | | | | | |
| | 0 | | | | | | | | | | | | |
| Station Use | 190 | 30 | 26 | 28 | 13 | 8 | 6 | 5 | 5 | 7 | 12 | 21 | 29 |
| System Use | 42 | 10 | 9 | 7 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 9 |
| | 0 | | | | | | | | | | | | |
| Losses | 3,739 | 686 | 512 | 518 | 255 | 168 | 107 | 121 | 118 | 94 | 197 | 455 | 509 |
| Sales | 7,252 | 888 | 754 | 766 | 612 | 434 | 404 | 402 | 406 | 408 | 486 | 718 | 975 |

| YEAR 2000 | | Totals | Jan | Feb | March | April | May | June | July | August | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Generation** | | **14,862** | **1,737** | **1,633** | **1,413** | **847** | **932** | **1,098** | **1,422** | **1,263** | **613** | **1,040** | **1,301** | **1,562** |
| **Thermal** | | **1,210** | **157** | **151** | **118** | **47** | **23** | **34** | **44** | **44** | **52** | **80** | **203** | **256** |
| **Hydro** | | **13,652** | **1,580** | **1,482** | **1,295** | **800** | **909** | **1,064** | **1,379** | **1,219** | **561** | **960** | **1,098** | **1,306** |
| | Toktogul | 5,580 | 689 | 628 | 522 | 295 | 331 | 422.1 | 572 | 510 | 224 | 388 | 454 | 545 |
| | Kurpsai | 3,719 | 430 | 410 | 358 | 217 | 242 | 286.6 | 377 | 335 | 152 | 260 | 298 | 354 |
| | UchKurgan | 1,061 | 120 | 116 | 100 | 69 | 77 | 82.1 | 102 | 88 | 39 | 77 | 86 | 106 |
| | Tashkumyr | 2,157 | 234 | 224 | 202 | 145 | 163 | 173.9 | 212 | 188 | 90 | 154 | 172 | 200 |
| | Shamaldysai | 897 | 89 | 86 | 79 | 59 | 69 | 74.2 | 91 | 81 | 38 | 66 | 77 | 90 |
| | Small Hydro | 25 | 7 | 8 | 4 | 1 | 3 | 2.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Small Hydro | 52 | 2 | 2 | 3 | 4 | 7 | 6.5 | 7 | 7 | 7 | 3 | 2 | 2 |
| | Small Hydro | 161 | 10 | 8 | 27 | 11 | 17 | 16.2 | 18 | 10 | 12 | 13 | 10 | 9 |
| | TPBishkek | 1,164 | 144 | 145 | 118 | 47 | 23 | 34 | 44 | 44 | 52 | 79 | 192 | 240 |
| | TP Osh | 46 | 12 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 16 |
| **Import** | | **320** | **0** | **0** | **0** | **0** | **19** | **67** | **39** | **0** | **45** | **33** | **22** | **95** |
| | Tajikistan | 126 | 0 | 0 | 0 | 0 | 19 | 67 | 39 | 0 | 0 | 0 | 0 | 0 |
| | Uzbekistan | 195 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 33 | 22 | 95 |
| | Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Turkmenistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Export** | | **3,153** | **103** | **56** | **52** | **117** | **368** | **614** | **907** | **722** | **132** | **75** | **3** | **5** |
| | Uzbekistan | 1,926 | 0 | 2 | 0 | 0 | 289 | 441 | 678 | 516 | 0 | 0 | 0 | 0 |
| | Kazakhstan | 1,073 | 103 | 52 | 24 | 9 | 63 | 173 | 229 | 205 | 132 | 75 | 3 | 5 |
| | Tajikistan | 154 | 0 | 2 | 28 | 108 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | China | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Losses in Kazakhstan | 179 | 28 | 27 | 22 | 8 | 8 | 6 | 6 | 6 | 7 | 17 | 19 | 24 |
| **Gross Consumption** | | **11,876** | **1,606** | **1,550** | **1,322** | **722** | **576** | **546** | **553** | **542** | **525** | **990** | **1,310** | **1,636** |
| | | 0 | | | | | | | | | | | | |
| | | 0 | | | | | | | | | | | | |
| Station Use | | 214 | 30 | 27 | 24 | 11 | 7 | 8 | 9 | 9 | 10 | 15 | 29 | 35 |
| System Use | | 44 | 10 | 9 | 6 | 1 | 0 | 0 | 1 | 1 | 1 | 3 | 4 | 9 |
| | | 0 | | | | | | | | | | | | |
| Losses | | 3,839 | 684 | 660 | 555 | 205 | 118 | 109 | 95 | 85 | 80 | 296 | 406 | 546 |
| Sales | | 7,779 | 882 | 854 | 738 | 506 | 451 | 428 | 447 | 447 | 434 | 676 | 871 | 1045 |

| YEAR 2001 | Totals | Jan | Feb | March | April | May | June | July | August | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Generation** | **13,553** | **1,666** | **1,553** | **1,265** | **845** | **682** | **955** | **1,286** | **1,075** | **705** | **870** | **1,039** | **1,612** |
| **Hydro** | **12,337** | **1,410** | **1,406** | **1,148** | **789** | **646** | **916** | **1,246** | **1,038** | **637** | **772** | **903** | **1,426** |
| **Thermal** | **1,215** | **256** | **146** | **117** | **56** | **36** | **39** | **40** | **37** | **67** | **98** | **136** | **186** |
| Toktogul | 4,787 | 565 | 556 | 431 | 277 | 211 | 347 | 506 | 417 | 247 | 301 | 357 | 571 |
| Kurpsay | 3,457 | 397 | 404 | 330 | 226 | 176 | 251 | 350 | 291 | 172 | 214 | 247 | 399 |
| Uch-Kurgan | 973 | 118 | 115 | 99 | 64 | 57 | 70 | 81 | 72 | 46 | 61 | 74 | 116 |
| Tashkumyr | 2,006 | 220 | 222 | 191 | 143 | 121 | 153 | 200 | 165 | 104 | 121 | 142 | 224 |
| Shamaldy-Say | 915 | 99 | 100 | 85 | 66 | 56 | 71 | 92 | 77 | 47 | 55 | 66 | 102 |
| Kemin | 50 | 2 | 2 | 3 | 4 | 7 | 6 | 7 | 7 | 6 | 3 | 2 | 2 |
| At-Bashy | 150 | 8 | 8 | 10 | 11 | 18 | 17 | 11 | 10 | 16 | 16 | 14 | 12 |
| Bishkek TPP | 1,166 | 241 | 135 | 110 | 56 | 36 | 39 | 40 | 37 | 67 | 98 | 136 | 171 |
| Osh TPP | 49 | 15 | 12 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| **Import** | **322** | **63** | **5** | **0** | **0** | **0** | **0** | **16** | **16** | **3** | **50** | **123** | **46** |
| Tajikistan | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 16 | 3 | 0 | 0 | 0 |
| Uzbekistan | 287 | 63 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 123 | 46 |
| Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Turkmenistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Export** | **2,165** | **10** | **13** | **45** | **44** | **87** | **419** | **739** | **567** | **160** | **68** | **12** | **1** |
| Uzbekistan | 1,038 | 0 | 0 | 0 | 0 | 48 | 245 | 458 | 287 | 0 | 0 | 0 | 0 |
| Kazakhstan | 1,049 | 10 | 9 | 4 | 11 | 39 | 175 | 282 | 280 | 160 | 68 | 11 | 1 |
| Tajikistan | 78 | 0 | 4 | 41 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| China | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Losses in Kazakhstan | 170 | 23 | 28 | 20 | 12 | 8 | 6 | 5 | 7 | 6 | 11 | 17 | 28 |
| **Gross Consumption** | **11,572** | **1,700** | **1,522** | **1,196** | **786** | **592** | **531** | **562** | **522** | **546** | **850** | **1,135** | **1,630** |
| | | | | | | | | | | | | | |
| Station Use | 219 | 36 | 28 | 22 | 11 | 8 | 8 | 10 | 10 | 11 | 16 | 25 | 34 |
| System Use | 22 | 7 | 8 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Losses | 4,806 | 813 | 652 | 445 | 252 | 171 | 152 | 169 | 148 | 150 | 382 | 533 | 939 |
| Sales | 6,525 | 844 | 833 | 724 | 522 | 412 | 371 | 383 | 364 | 385 | 452 | 577 | 658 |

# ANNEX B: LOAD FORECAST

| Year | Totals | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000 Gross Consumption GWh** | **11,876** | 1,606 | 1,550 | 1,322 | 722 | 576 | 546 | 553 | 542 | 525 | 990 | 1,310 | 1,636 |
| **2005 EnergyDemand GWh** | **12,482** | 1,688 | 1,629 | 1,389 | 759 | 605 | 574 | 581 | 570 | 552 | 1,040 | 1,377 | 1,719 |
| **System Load Factor %** | | 80 | 80 | 70 | 65 | 65 | 65 | 65 | 65 | 65 | 70 | 75 | 80 |
| **2005 Peak Demand** | | 2,890 | 2,789 | 2,719 | 1,599 | 1,276 | 1,209 | 1,225 | 1,201 | 1,163 | 2,036 | 2,515 | 2,944 |
| **2000 End Use GWh** | **9,700** | | | | | | | | | | | | |
| **2010 End Use GWh** | **11,037** | | | | | | | | | | | | |
| **2015 End Use GWh** | **11,774** | | | | | | | | | | | | |
| **Monthly Distribution (%)** | | 11.4 | 11.4 | 10.1 | 8.1 | 5.9 | 5.7 | 5.7 | 5.7 | 5.8 | 8.8 | 10.0 | 11.4 |
| **System Load Factor (%)** | | 65 | 65 | 65 | 55 | 55 | 55 | 55 | 55 | 55 | 65 | 65 | 65 |
| **2010 Energy Demand GWh** | **13,024** | 1,485 | 1,485 | 1,315 | 1,055 | 768 | 742 | 742 | 742 | 755 | 1,146 | 1,302 | 1,485 |
| **2010 Peak Demand ( MW)** | | 3,129 | 3,129 | 2,772 | 2,628 | 1,914 | 1,849 | 1,849 | 1,849 | 1,881 | 2,415 | 2,745 | 3,129 |
| **2015 Energy Demand GWh** | **13,893** | 1,584 | 1,584 | 1,403 | 1,125 | 820 | 792 | 792 | 792 | 806 | 1,223 | 1,389 | 1,584 |
| **2015 Peak Demand (MW)** | | 3,338 | 3,338 | 2,957 | 2,372 | 1,727 | 1,669 | 1,669 | 1,669 | 1,698 | 2,577 | 2,928 | 3,338 |

Assumptions:

1. **2005 Energy Demand assumes 1% annual growth in gross consumption.**

2. **Year 2000 end use is 2000 sales of 7,800 GWh plus 1,900 GWh (50% of losses) (see Annex A).**

3. **For 2010 and 2015, Annual growth in end use is 1,3 %.**

4. **Technical Losses: 18%.**

5. **Monthly energy distribution and system load factors as shown. See Annex A (Page 2) for 2000 load factors.**

# ANNEX C: HYDROPOWER PROJECTS: BASIC DATA

### Toktogul

| Pool Level | Gross Reservoir Capacity mcm V | Head m H | GWh/mcm | MW |
|---|---|---|---|---|
| 900 | 19,400 | 176 | 0.421 | 1200 |
| 890 | 17,000 | 164 | 0.394 | 1123 |
| 880 | 14,800 | 154 | 0.369 | 1052 |
| 870 | 12,500 | 143 | 0.343 | 977 |
| 860 | 10,400 | 133 | 0.319 | 910 |
| 850 | 8,000 | 122 | 0.292 | 832 |
| 840 | 6,000 | 112 | 0.269 | 768 |

H= 85+(V/212)
Gwh/mcm=H*2724*0.88/10^6

### Kambarata 1 (planned)

| Pool Level | Gross Recervoir Capacity mcm V | Head m H | GWh/mcm | MW |
|---|---|---|---|---|
| 1200 | 5080 | 242 | | |
| 1190 | 4,500 | 233 | 0.560 | 2000 |
| 1150 | 2,680 | 192 | 0.459 | 1645 |
| 1100 | 1,220 | 141 | 0.339 | 1213 |

H=87.8+48.12V-3.5V^2
Gwh/mcm=H*2724*0.88/10^6

| | |
|---|---|
| **Kambarata 2 (planned)** | Average head 50 m , Gwh/mcm=0.120 350 MW |
| **Kurpsai** | Average head 92 m , Gwh/mcm=0.221 800 MW |
| **Tashkumyr** | Average head 53 m , Gwh/mcm=0.127 450 MW |
| **Shamaldysai** | Average head 26 m , Gwh/mcm=0.062 240 MW |
| **Uch-Kurgan** | Average head 29 m , Gwh/mcm=0.070 180 MW |

# ANNEX D: Toktogul Operating Regime T 22 (Summer 22%, 2,700 mcm)

| | J | F | M | A | M | J | J | A | S | O | N | D | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Toktogul** | | | | | | | | | | | | | | | |
| Inflow mcm | 401 | 355 | 405 | 688 | 1,554 | 2,480 | 2,280 | 1,439 | 790 | 684 | 512 | 434 | 12,022 | | |
| Outflow mcm | 1,700 | 1,700 | 1,611 | 700 | 400 | 400 | 400 | 400 | 400 | 1,200 | 1,500 | 1,611 | 12,022 | | |
| Reservoir BOM | 16,888 | 15,589 | 14,244 | 13,038 | 13,026 | 14,180 | 16,260 | 18,140 | 19,179 | 19,500 | 18,984 | 17,996 | | | |
| Reservoir EOM | 15,589 | 14,244 | 13,038 | 13,026 | 14,180 | 16,260 | 18,140 | 19,179 | 19,400 | 18,984 | 17,996 | 16,819 | | | |
| Avg. Reservoir Content | 16,239 | 14,917 | 13,641 | 13,032 | 13,603 | 15,220 | 17,200 | 18,660 | 19,290 | 19,242 | 18,490 | 17,408 | | | |
| Head | 161 | 154 | 148 | 145 | 148 | 156 | 165 | 172 | 175 | 175 | 171 | 166 | | | |
| GWh/mcm | 0.385 | 0.370 | 0.356 | 0.349 | 0.355 | 0.373 | 0.396 | 0.412 | 0.419 | 0.419 | 0.410 | 0.398 | | | |
| MW | 999 | 918 | 839 | 802 | 837 | 937 | 1,058 | 1,148 | 1,187 | 1,184 | 1,138 | 1,071 | | | |
| GWh | 654 | 629 | 573 | 244 | 142 | 149 | 158 | 165 | 168 | 503 | 616 | 641 | 4,643 | | |
| | | | | | | | | | | | Summer | | 2,700 | | |
| **Kurpsai** | | | | | | | | | | | | | | | |
| Inflow mcm | 1,700 | 1,700 | 1,611 | 700 | 400 | 400 | 400 | 400 | 400 | 1,200 | 1,500 | 1,611 | 12,022 | | |
| GWh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | | | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | | | |
| GWh | 376 | 376 | 356 | 155 | 88 | 88 | 88 | 88 | 88 | 265 | 332 | 356 | 2,657 | | |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 | | |
| **Tashumyr** | | | | | | | | | | | | | | | |
| Inflow mcm | 1,750 | 1,745 | 1,682 | 881 | 662 | 611 | 531 | 476 | 455 | 1,252 | 1,552 | 1,655 | 13,252 | | |
| GWh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | | | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | | | |
| GWh | 222 | 222 | 214 | 112 | 84 | 78 | 67 | 60 | 58 | 159 | 197 | 210 | 1,683 | | |
| **Shamaldysai** | | | | | | | | | | | | | | | |
| Inflow mcm | 1,750 | 1,745 | 1,682 | 881 | 662 | 611 | 531 | 476 | 455 | 1,252 | 1,552 | 1,655 | 13,252 | | |
| GWh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | | | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | | | |
| GWh | 109 | 108 | 104 | 55 | 41 | 38 | 33 | 30 | 28 | 78 | 96 | 103 | 822 | | |
| **Uch Kurgan** | | | | | | | | | | | | | | | |
| Inflow mcm | 1,750 | 1,745 | 1,682 | 881 | 662 | 611 | 531 | 476 | 455 | 1,252 | 1,552 | 1,655 | 13,252 | | |
| GWh/mcm | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | | | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | | | |
| GWh | 123 | 122 | 118 | 62 | 46 | 43 | 37 | 33 | 32 | 88 | 109 | 116 | 928 | | |
| | | | | | | | | | | | | | | Winter | Summer |
| Total Hydro GWh | 1,483 | 1,457 | 1,365 | 627 | 402 | 396 | 384 | 377 | 374 | 1,092 | 1,349 | 1,426 | 10,732 | 8,172 | 2,560 |
| Total Hydro Capacity MW | 2,669 | 2,588 | 2,509 | 2,472 | 2,507 | 2,607 | 2,728 | 2,818 | 2,857 | 2,854 | 2,808 | 2,741 | | | 15,989 |
| | | | | | | | | | | | | | | | 0 |
| **2005 Energy Balance** | | | | | | | | | | | | | | | 0 |
| KYG Energy Demand | 1,688 | 1,629 | 1,389 | 759 | 605 | 574 | 581 | 570 | 552 | 1,040 | 1,377 | 1,719 | 12,484 | 8,843 | 3,641 |
| Hydro Surplus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 0 | 0 |
| Energy Deficit | 205 | 172 | 25 | 132 | 203 | 178 | 197 | 193 | 178 | 0 | 28 | 293 | 1,804 | 723 | 1,081 |
| Supplied by Fuel Imports | 205 | 172 | 25 | 132 | 203 | 178 | 197 | 193 | 178 | | 28 | 250 | 1,760 | 680 | 1,081 |
| Supplied by Energy Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 43 | 43 | 0 |
| Annual Deficit | | | | | | | | | | | | | 1,804 | 723 | 1,081 |
| **2005 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand 2005 MW | 2,890 | 2,789 | 2,719 | 1,599 | 1,276 | 1,209 | 1,225 | 1,201 | 1,163 | 2,036 | 2,515 | 2,944 | | | |
| Surplus Capacity | -221 | -202 | -210 | 873 | 1,231 | 1,397 | 1,504 | 1,618 | 1,694 | 818 | 293 | -203 | | | |

# ANNEX D: Toktogul Operating Regime T 55 (Summer 55%, 6,500 mcm)

| | J | F | M | A | M | J | J | A | S | O | N | D | | Winter | Summer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Toktogul** | | | | | | | | | | | | | | | |
| Inflow mcm | 401 | 355 | 405 | 688 | 1554 | 2480 | 2280 | 1439 | 790 | 684 | 512 | 434 | 12,022 | | |
| Outflow mcm | 855 | 1005 | 1055 | 900 | 1000 | 1300 | 1400 | 1300 | 600 | 698 | 905 | 1004 | 12,022 | | |
| Reservoir BOM | 18,503 | 18,049 | 17,399 | 16,749 | 16,537 | 17,091 | 18,271 | 19,151 | 19,290 | 19,400 | 19,386 | 18,993 | | | |
| Reservoir EOM | 18,049 | 17,399 | 16,749 | 16,537 | 17,091 | 18,271 | 19,151 | 19,290 | 19,400 | 19,386 | 18,993 | 18,423 | | | |
| Avg. Reservoir Content | 18,276 | 17,724 | 17,074 | 16,643 | 16,814 | 17,681 | 18,711 | 19,221 | 19,345 | 19,393 | 19,190 | 18,708 | | | |
| Head | 170 | 168 | 165 | 163 | 163 | 167 | 172 | 175 | 175 | 175 | 175 | 172 | | | |
| Gwh/mcm | 0.408 | 0.402 | 0.394 | 0.390 | 0.391 | 0.401 | 0.413 | 0.419 | 0.420 | 0.421 | 0.418 | 0.413 | | | |
| MW | 1125 | 1091 | 1051 | 1024 | 1035 | 1088 | 1151 | 1183 | 1190 | 1193 | 1181 | 1151 | | | |
| Gwh | 349 | 404 | 416 | 351 | 391 | 522 | 578 | 544 | 252 | 294 | 379 | 415 | 4,894 | | |
| | | | | | | | | | | | Summer | | 6,500 | | |
| **Kurpsai** | | | | | | | | | | | | | | | |
| Inflow mcm | 855 | 1005 | 1055 | 900 | 1000 | 1300 | 1400 | 1300 | 600 | 698 | 905 | 1004 | 12,022 | | |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | | | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | | | |
| Gwh | 189 | 222 | 233 | 199 | 221 | 287 | 309 | 287 | 133 | 154 | 200 | 222 | 2,657 | | |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 | | |
| **Tashkumyr** | | | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 | | |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | | | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | | | |
| Gwh | 115 | 133 | 143 | 137 | 160 | 192 | 194 | 175 | 83 | 95 | 122 | 133 | 1,683 | | |
| **Shamaldysai** | | | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 | | |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | | | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | | | |
| Gwh | 56 | 65 | 70 | 67 | 78 | 94 | 95 | 85 | 41 | 47 | 59 | 65 | 822 | | |
| **Uch Kurgan** | | | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 | | |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | | | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | | | |
| Gwh | 63 | 74 | 79 | 76 | 88 | 106 | 107 | 96 | 46 | 53 | 67 | 73 | 928 | | |
| Total Hydro Gwh | 772 | 898 | 941 | 829 | 939 | 1200 | 1284 | 1188 | 554 | 642 | 826 | 908 | 10,983 | 4,987 | 5,995 |
| Total Hydro Capacity | 2795 | 2761 | 2721 | 2694 | 2705 | 2758 | 2821 | 2853 | 2860 | 2863 | 2851 | 2821 | | | |
| **2005 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,688 | 1,629 | 1,389 | 759 | 605 | 574 | 581 | 570 | 552 | 1,040 | 1,377 | 1,719 | 12,484 | 8,843 | 3,641 |
| Hydro Surplus | 0 | 0 | 0 | 71 | 334 | 626 | 703 | 618 | 3 | 0 | 0 | 0 | 2,355 | 0 | 2,355 |
| Energy Defict: | 916 | 731 | 449 | 0 | 0 | 0 | 0 | 0 | 0 | 398 | 550 | 812 | 3,856 | 3,856 | 0 |
| From Fuel Imports | 250 | 250 | 250 | | | | | | | 250 | 250 | 250 | 1,500 | 1,500 | 0 |
| From Energy Imports | 666 | 481 | 199 | 0 | | | | | | 148 | 300 | 562 | 2,356 | 2,356 | 0 |
| Annual Deficit | | | | | | | | | | | | | 1,501 | | |
| **2005 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand 2005 MW | 2,890 | 2,789 | 2,719 | 1,599 | 1,276 | 1,209 | 1,225 | 1,201 | 1,163 | 2,036 | 2,515 | 2,944 | | | |
| Surplus/Deficit Capacity | -96 | -29 | 2 | 1095 | 1429 | 1549 | 1597 | 1652 | 1698 | 827 | 336 | -123 | | | |

## ANNEX D: Toktogul Operating Regime T 65 (Summer 65%: 7,840 mcm)

| | J | F | M | A | M | J | J | A | S | O | N | D | | Winter | Summer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Toktogul** | | | | | | | | | | | | | | | |
| Inflow mcm | 401 | 355 | 405 | 688 | 1554 | 2480 | 2280 | 1439 | 790 | 684 | 512 | 434 | 12022 | | |
| Outflow mcm | 771 | 660 | 660 | 1260 | 1360 | 1360 | 1300 | 1300 | 1260 | 660 | 660 | 771 | 12022 | | |
| Reservoir BOM | 18,500 | 18,130 | 17,825 | 17,570 | 16,998 | 17,192 | 18,312 | 19,292 | 19,431 | 19,400 | 19,424 | 19,276 | | | |
| Reservoir EOM | 18,130 | 17,825 | 17,570 | 16,998 | 17,192 | 18,312 | 19,292 | 19,431 | 19,500 | 19,424 | 19,276 | 18,939 | | | |
| Avg. Reservoir Content | 18,315 | 17,978 | 17,698 | 17,284 | 17,095 | 17,752 | 18,802 | 19,362 | 19,466 | 19,412 | 19,350 | 19,108 | | | |
| Head | 170 | 169 | 167 | 166 | 165 | 168 | 173 | 175 | 176 | 176 | 175 | 174 | | | |
| Gwh/mcm | 0.408 | 0.405 | 0.401 | 0.397 | 0.395 | 0.402 | 0.414 | 0.420 | 0.421 | 0.421 | 0.420 | 0.417 | | | |
| MW | 1127 | 1106 | 1089 | 1064 | 1052 | 1092 | 1157 | 1191 | 1198 | 1195 | 1191 | 1176 | | | |
| Gwh | 315 | 267 | 265 | 500 | 537 | 547 | 538 | 546 | 531 | 278 | 277 | 322 | 4923 | | |
| | | | | | | | | | | | Summer | | 7840 | | |
| **Kurpsai** | | | | | | | | | | | | | | | |
| Inflow mcm | 771 | 660 | 660 | 1260 | 1360 | 1360 | 1300 | 1300 | 1260 | 660 | 660 | 771 | 12022 | | |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | | | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | | | |
| Gwh | 170 | 146 | 146 | 278 | 301 | 301 | 287 | 287 | 278 | 146 | 146 | 170 | 2657 | | |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1230 | | |
| **Tashumyr** | | | | | | | | | | | | | | | |
| Inflow mcm | 821 | 705 | 731 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13252 | | |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | | | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | | | |
| Gwh | 104 | 90 | 93 | 183 | 206 | 200 | 182 | 175 | 167 | 90 | 90 | 104 | 1683 | | |
| **Shamaldysai** | | | | | | | | | | | | | | | |
| Inflow mcm | 821 | 705 | 731 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13252 | | |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | | | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | | | |
| Gwh | 51 | 44 | 45 | 89 | 101 | 97 | 89 | 85 | 82 | 44 | 44 | 51 | 822 | | |
| **Uch Kurgan** | | | | | | | | | | | | | | | |
| Inflow mcm | 821 | 705 | 731 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13252 | | |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | | | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | | | |
| Gwh | 57 | 49 | 51 | 101 | 114 | 110 | 100 | 96 | 92 | 50 | 50 | 57 | 928 | | |
| Total Hydro Gwh | 698 | 596 | 600 | 1152 | 1257 | 1254 | 1196 | 1190 | 1150 | 608 | 608 | 703 | 11012 | 3813 | 7200 |
| Total Hydro Capacity | 2797 | 2776 | 2759 | 2734 | 2722 | 2762 | 2827 | 2861 | 2868 | 2865 | 2861 | 2846 | | | |
| **2005 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,688 | 1,629 | 1,389 | 759 | 605 | 574 | 581 | 570 | 552 | 1,040 | 1,377 | 1,719 | 12,484 | 8,843 | 3,641 |
| Hydro Surplus | 0 | 0 | 0 | 393 | 652 | 680 | 615 | 620 | 598 | 0 | 0 | 0 | 3,559 | 0 | 3,559 |
| Energy Deficit | 990 | 1,034 | 789 | | | | | | | 432 | 769 | 1,016 | 5,031 | 5,031 | 0 |
| From Fuel Imports | 250 | 250 | 250 | | | | | | | 250 | 250 | 250 | 1,500 | 1,500 | 0 |
| From Energy Imports | 740 | 784 | 539 | | | | | | | 182 | 519 | 766 | 3,531 | 3,531 | 0 |
| Annual Deficit | | | | | | | | | | | | | 1,472 | | |
| **2005 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand 2005 MW | 2,890 | 2,789 | 2,719 | 1,599 | 1,276 | 1,209 | 1,225 | 1,201 | 1,163 | 2,036 | 2,515 | 2,944 | | | |
| Surplus/Deficit Capacity | -93 | -13 | 40 | 1134 | 1446 | 1553 | 1602 | 1661 | 1705 | 828 | 346 | -98 | | | |

## ANNEX E: KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
## ALTERNATIVE A

TOKTOGUL REGIME T65 (7,840 BCM RELEASE,APRIL TO SEPTEMBER)
K#1 RULE CURVE RW TO MAXIMIZE WINTER ENERGY

| | J | F | M | A | M | J | J | A | S | O | N | D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kambarata #1** | | | | | | | | | | | | | |
| Inflow mcm | 324 | 342 | 379 | 673 | 1353 | 2201 | 1857 | 1256 | 711 | 523 | 458 | 384 | 10,463 |
| Rule Curve | 0.45 | 0.25 | 0.10 | 0.08 | 0.25 | 0.65 | 0.95 | 1.00 | 1.00 | 0.90 | 0.80 | 0.65 | |
| Outflow mcm | 1,224 | 1,242 | 1,054 | 763 | 588 | 401 | 507 | 1,031 | 711 | 973 | 908 | 1,059 | 10,463 |
| Reservoir BOM | 2,925 | 2,025 | 1,125 | 450 | 360 | 1,125 | 2,925 | 4,275 | 4,500 | 4,500 | 4,050 | 3,600 | |
| Reservoir EOM | 2,025 | 1,125 | 450 | 360 | 1,125 | 2,925 | 4,275 | 4,500 | 4,500 | 4,050 | 3,600 | 2,925 | |
| Avg. Reservoir Content | 2,475 | 1,575 | 788 | 405 | 743 | 2,025 | 3,600 | 4,388 | 4,500 | 4,275 | 3,825 | 3,263 | |
| Avg.Head | 185 | 155 | 124 | 107 | 122 | 171 | 216 | 232 | 233 | 230 | 221 | 208 | |
| Gwh/mcm | 0.445 | 0.371 | 0.296 | 0.256 | 0.291 | 0.410 | 0.517 | 0.555 | 0.560 | 0.550 | 0.529 | 0.497 | |
| MW | 953 | 796 | 635 | 548 | 625 | 878 | 1108 | 1190 | 1200 | 1180 | 1134 | 1067 | |
| Gwh | 544 | 461 | 312 | 195 | 171 | 164 | 262 | 572 | 398 | 536 | 480 | 527 | 4,624 |
| Full gate Gwh | 696 | 581 | 463 | 400 | 456 | 641 | 809 | 869 | 876 | 861 | 828 | 779 | |
| Plant factor % | 78 | 79 | 67 | 49 | 38 | 26 | 32 | 66 | 45 | 62 | 58 | 68 | |
| **Kambarata #2** | | | | | | | | | | | | | |
| Inflow | 1,224 | 1,242 | 1,054 | 763 | 588 | 401 | 507 | 1,031 | 711 | 973 | 908 | 1,059 | |
| Outflow | 1224 | 1242 | 1054 | 763 | 588 | 401 | 507 | 1031 | 711 | 973 | 908 | 1059 | |
| Gwh/mcm | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| MW | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | |
| Gwh | 147 | 149 | 127 | 92 | 71 | 48 | 61 | 124 | 85 | 117 | 109 | 127 | 1,256 |
| Full Gate Output | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | |
| Plant Factor | 34 | 34 | 29 | 21 | 16 | 11 | 14 | 28 | 19 | 27 | 25 | 29 | |
| Tributary Inflow mcm | 77 | 13 | 26 | 15 | 191 | 289 | 423 | 183 | 79 | 161 | 54 | 50 | 1,560 |
| **Toktogul** | | | | | | | | | | | | | |
| Inflow mcm | 1301 | 1255 | 1080 | 778 | 779 | 690 | 930 | 1214 | 790 | 1134 | 962 | 1109 | 12,022 |
| Outflow mcm | 660 | 660 | 771 | 1260 | 1360 | 1360 | 1300 | 1300 | 1260 | 660 | 660 | 771 | 12,022 |
| Reservoir BOM | 18,000 | 18,641 | 19,236 | 19,545 | 19,063 | 18,482 | 17,812 | 17,442 | 17,356 | 19,000 | 19,474 | 19,000 | |
| Reservoir EOM | 18,641 | 19,236 | 19,545 | 19,063 | 18,482 | 17,812 | 17,442 | 17,356 | 16,886 | 19,474 | 19,400 | 19,338 | |
| Avg. Reservoir Content | 18,321 | 18,939 | 19,391 | 19,304 | 18,773 | 18,147 | 17,627 | 17,399 | 17,121 | 19,237 | 19,437 | 19,169 | |
| Head | 170 | 173 | 175 | 175 | 173 | 170 | 167 | 166 | 165 | 175 | 176 | 174 | |
| Gwh/mcm | 0.409 | 0.415 | 0.421 | 0.420 | 0.414 | 0.407 | 0.401 | 0.398 | 0.395 | 0.419 | 0.421 | 0.418 | |
| MW | 1127 | 1165 | 1193 | 1188 | 1155 | 1117 | 1085 | 1071 | 1054 | 1184 | 1196 | 1180 | |
| Gwh | 270 | 274 | 324 | 529 | 563 | 553 | 521 | 518 | 498 | 276 | 278 | 322 | 4,925 |
| Plant Factor | 33 | 32 | 37 | 61 | 67 | 68 | 66 | 66 | 65 | 32 | 32 | 37 | |
| | | | | | | | | | | | Summer | | 7,840 |
| **Kurpsai** | | | | | | | | | | | | | |
| Inflow mcm | 660 | 660 | 771 | 1260 | 1360 | 1360 | 1300 | 1300 | 1260 | 660 | 660 | 771 | 12,022 |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | |
| Gwh | 146 | 146 | 170 | 278 | 301 | 301 | 287 | 287 | 278 | 146 | 146 | 170 | 2,657 |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 |
| **Tashkumyr** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13,252 |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | |
| Gwh | 90 | 90 | 107 | 183 | 206 | 200 | 182 | 175 | 167 | 90 | 90 | 104 | 1,683 |
| **Shamaldysai** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13,252 |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | |
| Gwh | 44 | 44 | 52 | 89 | 101 | 97 | 89 | 85 | 82 | 44 | 44 | 51 | 822 |
| **Uch Kurgan** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1441 | 1622 | 1571 | 1431 | 1376 | 1315 | 712 | 712 | 815 | 13,252 |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | |
| Gwh | 50 | 49 | 59 | 101 | 114 | 110 | 100 | 96 | 92 | 50 | 50 | 57 | 928 |
| Cascade Hydro | 599 | 603 | 713 | 1,180 | 1,283 | 1,260 | 1,179 | 1,161 | 1,117 | 607 | 608 | 704 | 11,014 |
| Total Hydro GWh | 1,291 | 1,213 | 1,151 | 1,467 | 1,525 | 1,473 | 1,502 | 1,857 | 1,600 | 1,259 | 1,197 | 1,358 | 16,893 |
| Hydro Capacity MW | 4,351 | 4,232 | 4,098 | 4,006 | 4,050 | 4,265 | 4,463 | 4,531 | 4,523 | 4,634 | 4,600 | 4,516 | |

## SUMMARY ALTERNATIVE A: T65/RW

| | J | F | M | A | M | J | J | A | S | O | N | D | TOTALS ANNUAL | WINTER | SUMMER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Hydro GWh | 1,291 | 1,213 | 1,151 | 1,467 | 1,525 | 1,473 | 1,502 | 1,857 | 1,600 | 1,259 | 1,197 | 1,358 | 16,893 | 7,469 | 9,424 |
| Hydro Capacity MW | 4,351 | 4,232 | 4,098 | 4,006 | 4,050 | 4,265 | 4,463 | 4,531 | 4,523 | 4,634 | 4,600 | 4,516 | | | |
| **2010 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,485 | 1,485 | 1,315 | 1,055 | 768 | 742 | 742 | 742 | 755 | 1,146 | 1,302 | 1,485 | 13,024 | 8,218 | 4,806 |
| Hydro Surplus | 0 | 0 | 0 | 412 | 757 | 731 | 760 | 1,115 | 845 | 113 | 0 | 0 | 4,731 | 113 | 4,618 |
| Thermal Deficit | 194 | 272 | 164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 127 | 862 | 862 | 0 |
| Supplied by Fuel Imports | 194 | 250 | 164 | | | | | | | 0 | 105 | 127 | 840 | 840 | 0 |
| Supplied by Energy Impo | 0 | 22 | 0 | | | | | | | | 0 | 0 | 22 | 22 | 0 |
| Annual Energy Surplus | | | | | | | | | | | | | 3,869 | | 0 |
| **2010 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand | 3,129 | 3,129 | 2,772 | 2,628 | 1,914 | 1,849 | 1,849 | 1,849 | 1,881 | 2,415 | 2,745 | 3,129 | | | |
| Surplus Capacity | 1,221 | 1,102 | 1,326 | 1,379 | 2,136 | 2,416 | 2,614 | 2,682 | 2,642 | 2,218 | 1,855 | 1,387 | | | |
| **2015 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,584 | 1,584 | 1,403 | 1,125 | 820 | 792 | 792 | 792 | 806 | 1,223 | 1,389 | 1,584 | 13,893 | 8,766 | 5,127 |
| Hydro Surplus | 0 | 0 | 0 | 342 | 706 | 681 | 710 | 1,065 | 794 | 36 | 0 | 0 | 4,334 | 36 | 4,298 |
| Thermal Deficit | 293 | 371 | 252 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 192 | 226 | 1,334 | 1,334 | 0 |
| Supplied by Fuel Imports | 250 | 250 | 250 | | | | | | | 0 | 192 | 226 | 1,168 | 1,168 | 0 |
| Supplied by Energy Impo | 43 | 121 | 2 | | | | | | | 0 | 0 | 0 | 166 | 166 | 0 |
| Annual Energy Surplus | | | | | | | | | | | | | 3,000 | 3,000 | 0 |
| **2015 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand MW | 3,338 | 3,338 | 2,957 | 2,372 | 1,727 | 1,669 | 1,669 | 1,669 | 1,698 | 2,577 | 2,928 | 3,338 | | | |
| Surplus Capacity | 1,013 | 894 | 1,141 | 1,635 | 2,323 | 2,596 | 2,794 | 2,862 | 2,825 | 2,057 | 1,672 | 1,178 | | | |

## ANNEX E: KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
## ALTERNATIVE B

**TOKTOGUL REGIME T65 (7,840 BCM RELEASE,APRIL TO SEPTEMBER)**
**K1 RULE CURVE RA TO MAXIMIZE ANNUAL ENERGY**

| | J | F | M | A | M | J | J | A | S | O | N | D | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kambarata #1** | | | | | | | | | | | | | |
| Inflow mcm | 324 | 342 | 379 | 673 | 1,353 | 2,201 | 1,857 | 1,256 | 711 | 523 | 458 | 384 | 10463 |
| Rule Curve | 0.94 | 0.91 | 0.89 | 0.90 | 0.90 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.97 | |
| Outflow mcm | 459 | 477 | 469 | 628 | 1,353 | 2,201 | 1,407 | 1,256 | 711 | 523 | 503 | 474 | 10463 |
| Reservoir BOM | 4,365 | 4,230 | 4,095 | 4,005 | 4,050 | 4,050 | 4,050 | 4,500 | 4,500 | 4,500 | 4,500 | 4,455 | |
| Reservoir EOM | 4,230 | 4,095 | 4,005 | 4,050 | 4,050 | 4,050 | 4,500 | 4,500 | 4,500 | 4,500 | 4,455 | 4,365 | |
| Avg. Reservoir Content | 4,298 | 4,163 | 4,050 | 4,028 | 4,050 | 4,050 | 4,275 | 4,500 | 4,500 | 4,500 | 4,478 | 4,410 | |
| Avg.Head | 230 | 227 | 225 | 225 | 225 | 225 | 230 | 233 | 233 | 233 | 233 | 232 | |
| Gwh/mcm | 0.551 | 0.545 | 0.540 | 0.539 | 0.540 | 0.540 | 0.550 | 0.560 | 0.560 | 0.560 | 0.559 | 0.556 | |
| MW | 1,182 | 1,169 | 1,158 | 1,155 | 1,158 | 1,158 | 1,180 | 1,200 | 1,200 | 1,200 | 1,198 | 1,192 | |
| Gwh | 253 | 260 | 253 | 338 | 731 | 1,189 | 774 | 703 | 398 | 293 | 281 | 263 | 5,737 |
| Full gate Gwh | 863 | 853 | 845 | 843 | 845 | 845 | 861 | 876 | 876 | 876 | 874 | 870 | |
| Plant factor % | 29 | 30 | 30 | 40 | 86 | 141 | 90 | 80 | 45 | 33 | 32 | 30 | |
| **Kambarata #2** | | | | | | | | | | | | | |
| Inflow | 459 | 477 | 469 | 628 | 1,353 | 2,201 | 1,407 | 1,256 | 711 | 523 | 503 | 474 | 10,463 |
| Outflow | 459 | 477 | 469 | 628 | 1,353 | 2,201 | 1,407 | 1,256 | 711 | 523 | 503 | 474 | |
| Gwh/mcm | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| MW | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | |
| Gwh | 55 | 57 | 56 | 75 | 162 | 264 | 169 | 151 | 85 | 63 | 60 | 57 | 1,256 |
| Full Gate Output | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | |
| Plant Factor | 13 | 13 | 13 | 17 | 37 | 60 | 39 | 34 | 19 | 14 | 14 | 13 | |
| Tributary Inflow mcm | 77 | 13 | 26 | 15 | 191 | 289 | 423 | 183 | 79 | 161 | 54 | 50 | 1,560 |
| **Toktogul** | | | | | | | | | | | | | |
| Inflow mcm | 536 | 490 | 495 | 643 | 1,544 | 2,490 | 1,830 | 1,439 | 790 | 684 | 557 | 524 | 12,022 |
| Outflow mcm | 660 | 660 | 771 | 1,260 | 1,360 | 1,360 | 1,300 | 1,300 | 1,260 | 771 | 660 | 660 | 12,022 |
| Reservoir BOM | 18,000 | 17,876 | 17,706 | 17,430 | 16,813 | 16,997 | 18,127 | 18,657 | 18,796 | 19,000 | 18,913 | 19,000 | |
| Reservoir EOM | 17,876 | 17,706 | 17,430 | 16,813 | 16,997 | 18,127 | 18,657 | 18,796 | 18,326 | 18,913 | 19,400 | 18,864 | |
| Avg. Reservoir Content | 17,938 | 17,791 | 17,568 | 17,122 | 16,905 | 17,562 | 18,392 | 18,727 | 18,561 | 18,957 | 19,157 | 18,932 | |
| Head | 169 | 168 | 167 | 165 | 164 | 167 | 171 | 172 | 172 | 173 | 174 | 173 | |
| Gwh/mcm | 0.404 | 0.403 | 0.400 | 0.395 | 0.393 | 0.400 | 0.409 | 0.413 | 0.411 | 0.416 | 0.418 | 0.415 | |
| MW | 1,104 | 1,095 | 1,081 | 1,054 | 1,040 | 1,081 | 1,132 | 1,152 | 1,142 | 1,167 | 1,179 | 1,165 | |
| Gwh | 267 | 266 | 308 | 498 | 534 | 544 | 532 | 537 | 518 | 321 | 276 | 274 | 4,874 |
| Plant Factor | 33 | 33 | 39 | 65 | 70 | 69 | 64 | 64 | 62 | 38 | 32 | 32 | |
| | | | | | | | | | | | Summer | | 7,840 |
| **Kurpsai** | | | | | | | | | | | | | |
| Inflow mcm | 660 | 660 | 771 | 1,260 | 1,360 | 1,360 | 1,300 | 1,300 | 1,260 | 771 | 660 | 660 | 12,022 |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | |
| Gwh | 146 | 146 | 170 | 278 | 301 | 301 | 287 | 287 | 278 | 170 | 146 | 146 | 2,657 |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 |
| **Tashkumyr** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1,441 | 1,622 | 1,571 | 1,431 | 1,376 | 1,315 | 823 | 712 | 704 | 13,252 |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | |
| Gwh | 90 | 90 | 107 | 183 | 206 | 200 | 182 | 175 | 167 | 105 | 90 | 89 | 1,683 |
| **Shamaldysai** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1,441 | 1,622 | 1,571 | 1,431 | 1,376 | 1,315 | 823 | 712 | 704 | 13,252 |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | |
| Gwh | 44 | 44 | 52 | 89 | 101 | 97 | 89 | 85 | 82 | 51 | 44 | 44 | 822 |
| **Uch Kurgan** | | | | | | | | | | | | | |
| Inflow mcm | 710 | 705 | 842 | 1,441 | 1,622 | 1,571 | 1,431 | 1,376 | 1,315 | 823 | 712 | 704 | 13,252 |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | |
| Gwh | 50 | 49 | 59 | 101 | 114 | 110 | 100 | 96 | 92 | 58 | 50 | 49 | 928 |
| Cascade Hydro | 597 | 594 | 697 | 1,149 | 1,254 | 1,251 | 1,190 | 1,181 | 1,137 | 704 | 606 | 602 | 10,963 |
| Total Hydro Gwh | 905 | 911 | 1,007 | 1,563 | 2,148 | 2,704 | 2,133 | 2,034 | 1,621 | 1,060 | 948 | 923 | 17,956 |
| Hydro Capacity | 4,556 | 4,534 | 4,509 | 4,479 | 4,468 | 4,508 | 4,582 | 4,622 | 4,612 | 4,636 | 4,647 | 4,627 | |

**SUMMARY ALTERNATIVE B: T65/RA**

| | J | F | M | A | M | J | J | A | S | O | N | D | | WINTER | SUMMER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Hydro Gwh | 905 | 911 | 1,007 | 1,563 | 2,148 | 2,704 | 2,133 | 2,034 | 1,621 | 1,060 | 948 | 923 | 17,956 | 5,753 | 12,203 |
| Peaking Capacity | 4,556 | 4,534 | 4,509 | 4,479 | 4,468 | 4,508 | 4,582 | 4,622 | 4,612 | 4,636 | 4,647 | 4,627 | | | |
| **2010 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,485 | 1,485 | 1,315 | 1,055 | 768 | 742 | 742 | 742 | 755 | 1,146 | 1,302 | 1,485 | 13,024 | 8,218 | 4,806 |
| Hydro Surplus | 0 | 0 | 0 | 508 | 1,379 | 1,962 | 1,391 | 1,292 | 865 | 0 | 0 | 0 | 7,397 | 0 | 7,397 |
| Thermal Deficit | 580 | 573 | 309 | 0 | 0 | 0 | 0 | 0 | 0 | 86 | 355 | 562 | 2,465 | 2,465 | 0 |
| Supplied by Fuel Import: | 250 | 250 | 250 | | | | | | | 59 | 250 | 250 | 1,309 | 1,309 | 0 |
| Supplied by Energy Imp | 330 | 323 | 59 | | | | | | | 27 | 105 | 312 | 1,156 | 1,156 | 0 |
| Annual Surplus | | | | | | | | | | | | | 4,932 | | |
| **2010 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand MW | 3,129 | 3,129 | 2,772 | 2,628 | 1,914 | 1,849 | 1,849 | 1,849 | 1,881 | 2,415 | 2,745 | 3,129 | | | |
| Surplus Capacity | 1,427 | 1,405 | 1,737 | 1,852 | 2,554 | 2,659 | 2,733 | 2,773 | 2,731 | 2,221 | 1,902 | 1,498 | | | |
| **2015 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,584 | 1,584 | 1,403 | 1,125 | 820 | 792 | 792 | 792 | 806 | 1,223 | 1,389 | 1,584 | 13,893 | 8,766 | 5,127 |
| Hydro Surplus | 0 | 0 | 0 | 438 | 1,328 | 1,912 | 1,341 | 1,242 | 815 | 0 | 0 | 0 | 7,077 | 0 | 7,077 |
| Thermal Deficit | 679 | 672 | 397 | 0 | 0 | 0 | 0 | 0 | 0 | 163 | 442 | 661 | 3,014 | 3,014 | 0 |
| Supplied by Fuel Import | 250 | 250 | 250 | | | | | | | 163 | 250 | 250 | 1,500 | 1,500 | 0 |
| Supplied by Energy Im| | 429 | 422 | 147 | | | | | | | 0 | 192 | 411 | 1,514 | 1,514 | 0 |
| Annual Surplus | | | | | | | | | | | | | 4,063 | | |
| **2015 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand MW | 3,338 | 3,338 | 2,957 | 2,372 | 1,727 | 1,669 | 1,669 | 1,669 | 1,698 | 2,577 | 2,928 | 3,338 | | | |
| Surplus Capacity | 1,218 | 1,196 | 1,552 | 2,107 | 2,741 | 2,840 | 2,913 | 2,953 | 2,914 | 2,060 | 1,719 | 1,289 | | | |

## ANNEX E:KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
## ALTERNATIVE C

**TOKTOGUL REGIME T55 (6,500 BCM RELEASE,APRIL TO SEPTEMBER)**
**K#1 RULE CURVE RW TO MAXIMIZE WINTER ENERGY**

| | J | F | M | A | M | J | J | A | S | O | N | D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kambarata #1** | | | | | | | | | | | | | |
| Inflow mcm | 324 | 342 | 379 | 673 | 1353 | 2201 | 1857 | 1256 | 711 | 523 | 458 | 384 | 10,463 |
| Rule Curve | 0.45 | 0.25 | 0.10 | 0.08 | 0.25 | 0.65 | 0.95 | 1.00 | 1.00 | 0.90 | 0.80 | 0.65 | |
| Outflow mcm | 1,224 | 1,242 | 1,054 | 763 | 588 | 401 | 507 | 1,031 | 711 | 973 | 908 | 1,059 | 10,463 |
| Reservoir BOM | 2,925 | 2,025 | 1,125 | 450 | 360 | 1,125 | 2,925 | 4,275 | 4,500 | 4,500 | 4,050 | 3,600 | |
| Reservoir EOM | 2,025 | 1,125 | 450 | 360 | 1,125 | 2,925 | 4,275 | 4,500 | 4,500 | 4,050 | 3,600 | 2,925 | |
| Avg. Reservoir Content | 2,475 | 1,575 | 788 | 405 | 743 | 2,025 | 3,600 | 4,388 | 4,500 | 4,275 | 3,825 | 3,263 | |
| Avg.Head | 185 | 155 | 124 | 107 | 122 | 171 | 216 | 232 | 233 | 230 | 221 | 208 | |
| Gwh/mcm | 0.445 | 0.371 | 0.296 | 0.256 | 0.291 | 0.410 | 0.517 | 0.555 | 0.560 | 0.550 | 0.529 | 0.497 | |
| MW | 953 | 796 | 635 | 548 | 625 | 878 | 1108 | 1190 | 1200 | 1180 | 1134 | 1067 | |
| Gwh | 544 | 461 | 312 | 195 | 171 | 164 | 262 | 572 | 398 | 536 | 480 | 527 | 4,624 |
| Full gate Gwh | 696 | 581 | 463 | 400 | 456 | 641 | 809 | 869 | 876 | 861 | 828 | 779 | |
| Plant factor % | 78 | 79 | 67 | 49 | 38 | 26 | 32 | 66 | 45 | 62 | 58 | 68 | |
| **Kambarata #2** | | | | | | | | | | | | | |
| Inflow | 1,224 | 1,242 | 1,054 | 763 | 588 | 401 | 507 | 1,031 | 711 | 973 | 908 | 1,059 | |
| Outflow | 1224 | 1242 | 1054 | 763 | 588 | 401 | 507 | 1031 | 711 | 973 | 908 | 1059 | |
| Gwh/mcm | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| MW | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | |
| Gwh | 147 | 149 | 127 | 92 | 71 | 48 | 61 | 124 | 85 | 117 | 109 | 127 | 1,256 |
| Full Gate Output | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | |
| Plant Factor | 34 | 34 | 29 | 21 | 16 | 11 | 14 | 28 | 19 | 27 | 25 | 29 | |
| Tributary Inflow mcm | 77 | 13 | 26 | 15 | 191 | 289 | 423 | 183 | 79 | 161 | 54 | 50 | 1,560 |
| **Toktogul** | | | | | | | | | | | | | |
| Inflow mcm | 1301 | 1255 | 1080 | 778 | 779 | 690 | 930 | 1214 | 790 | 1134 | 962 | 1109 | 12,022 |
| Outflow mcm | 855 | 1005 | 1055 | 900 | 1000 | 1300 | 1400 | 1300 | 600 | 698 | 905 | 1004 | 12,022 |
| Reservoir BOM | 18,000 | 18,446 | 18,696 | 18,721 | 18,599 | 18,378 | 17,768 | 17,298 | 17,212 | 19,000 | 19,436 | 19,000 | |
| Reservoir EOM | 18,446 | 18,696 | 18,721 | 18,599 | 18,378 | 17,768 | 17,298 | 17,212 | 17,402 | 19,436 | 19,400 | 19,105 | |
| Avg. Reservoir Content | 18,223 | 18,571 | 18,709 | 18,660 | 18,489 | 18,073 | 17,533 | 17,255 | 17,307 | 19,218 | 19,418 | 19,053 | |
| Head | 170 | 172 | 172 | 172 | 171 | 169 | 167 | 165 | 166 | 175 | 176 | 174 | |
| Gwh/mcm | 0.407 | 0.411 | 0.413 | 0.412 | 0.410 | 0.406 | 0.400 | 0.396 | 0.397 | 0.419 | 0.421 | 0.417 | |
| MW | 1121 | 1143 | 1151 | 1148 | 1138 | 1112 | 1079 | 1062 | 1065 | 1183 | 1195 | 1172 | |
| Gwh | 348 | 413 | 436 | 371 | 410 | 527 | 559 | 515 | 238 | 292 | 381 | 418 | 4,911 |
| Plant Factor | 43 | 50 | 52 | 44 | 49 | 65 | 71 | 66 | 31 | 34 | 44 | 49 | |
| | | | | | | | | | | | Summer | | 6,500 |
| **Kurpsai** | | | | | | | | | | | | | |
| Inflow mcm | 855 | 1005 | 1055 | 900 | 1000 | 1300 | 1400 | 1300 | 600 | 698 | 905 | 1004 | 12,022 |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | |
| Gwh | 189 | 222 | 233 | 199 | 221 | 287 | 309 | 287 | 133 | 154 | 200 | 222 | 2,657 |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 |
| **Tashkumyr** | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | |
| Gwh | 115 | 133 | 143 | 137 | 160 | 192 | 194 | 175 | 83 | 95 | 122 | 133 | 1,683 |
| **Shamaldysai** | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | |
| Gwh | 56 | 65 | 70 | 67 | 78 | 94 | 95 | 85 | 41 | 47 | 59 | 65 | 822 |
| **Uch Kurgan** | | | | | | | | | | | | | |
| Inflow mcm | 905 | 1050 | 1126 | 1081 | 1262 | 1511 | 1531 | 1376 | 655 | 750 | 957 | 1048 | 13,252 |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | |
| Gwh | 63 | 74 | 79 | 76 | 88 | 106 | 107 | 96 | 46 | 53 | 67 | 73 | 928 |
| Cascade Hydro | 772 | 907 | 960 | 850 | 958 | 1,206 | 1,265 | 1,159 | 540 | 641 | 829 | 912 | 11,000 |
| Total Hydro GWh | 1,463 | 1,518 | 1,399 | 1,137 | 1,200 | 1,419 | 1,588 | 1,855 | 1,024 | 1,293 | 1,418 | 1,566 | 16,879 |
| Hydro Capacity MW | 4,345 | 4,209 | 4,056 | 3,967 | 4,033 | 4,260 | 4,457 | 4,522 | 4,535 | 4,632 | 4,599 | 4,509 | |

## SUMMARY ALTERNATIVE C: T55/RW

| | J | F | M | A | M | J | J | A | S | O | N | D | TOTALS ANNUAL | WINTER | SUMMER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Hydro GWh | 1,463 | 1,518 | 1,399 | 1,137 | 1,200 | 1,419 | 1,588 | 1,855 | 1,024 | 1,293 | 1,418 | 1,566 | 16,879 | 8,656 | 8,223 |
| Hydro Capacity MW | 4,345 | 4,209 | 4,056 | 3,967 | 4,033 | 4,260 | 4,457 | 4,522 | 4,535 | 4,632 | 4,599 | 4,509 | | | |
| **2010 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,485 | 1,485 | 1,315 | 1,055 | 768 | 742 | 742 | 742 | 755 | 1,146 | 1,302 | 1,485 | 13,024 | 8,218 | 4,806 |
| Hydro Surplus | 0 | 33 | 84 | 82 | 432 | 676 | 846 | 1,113 | 269 | 147 | 116 | 81 | 3,679 | | |
| Thermal Deficit | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 22 | 0 |
| Supplied by Fuel Imports | 22 | 0 | 0 | 0 | | | | | | | 0 | 0 | 22 | 22 | 0 |
| Supplied by Energy Imp | 0 | 0 | 0 | 0 | | | | | | | 0 | 0 | 0 | 0 | 0 |
| Annual Surplus | | | | | | | | | | | | | 3,657 | | |
| **2010 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand | 3,129 | 3,129 | 2,772 | 2,628 | 1,914 | 1,849 | 1,849 | 1,849 | 1,881 | 2,415 | 2,745 | 3,129 | | | |
| Surplus Capacity | 1,215 | 1,080 | 1,284 | 1,339 | 2,119 | 2,411 | 2,608 | 2,673 | 2,653 | 2,217 | 1,854 | 1,380 | | | |
| **2015 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,584 | 1,584 | 1,403 | 1,125 | 820 | 792 | 792 | 792 | 806 | 1,223 | 1,389 | 1,584 | 13,893 | 8,766 | 5,127 |
| Hydro Surplus | 0 | 0 | 0 | 11 | 381 | 627 | 797 | 1,063 | 218 | 70 | 29 | 0 | 3,196 | | |
| Thermal Deficit | 121 | 66 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 209 | 209 | 0 |
| Supplied by Fuel Import | 121 | 66 | 4 | 0 | | | | | | 0 | 0 | 18 | 209 | 209 | 0 |
| Supplied by Energy Imp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annual Surplus | | | | | | | | | | | | | 2,986 | | |
| **2015 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand MW | 3,338 | 3,338 | 2,957 | 2,372 | 1,727 | 1,669 | 1,669 | 1,669 | 1,698 | 2,577 | 2,928 | 3,338 | | | |
| Surplus Capacity | 1,007 | 871 | 1,099 | 1,595 | 2,305 | 2,592 | 2,788 | 2,853 | 2,837 | 2,056 | 1,671 | 1,171 | | | |

# ANNEX E:KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE

## ALTERNATIVE D

**TOKTOGUL REGIME T55 (6,500 BCM RELEASE,APRIL TO SEPTEMBER)**
**K#1 RULE CURVE RA TO MAXIMIZE ANNUAL ENERGY**

| | J | F | M | A | M | J | J | A | S | O | N | D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kambarata #1** | | | | | | | | | | | | | |
| Inflow mcm | 324 | 342 | 379 | 673 | 1353 | 2201 | 1857 | 1256 | 711 | 523 | 458 | 384 | 10,463 |
| Rule Curve | 0.94 | 0.91 | 0.89 | 0.90 | 0.90 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.97 | |
| Outflow mcm | 459 | 477 | 469 | 628 | 1,353 | 2,201 | 1,407 | 1,256 | 711 | 523 | 503 | 474 | 10,463 |
| Reservoir BOM | 4,365 | 4,230 | 4,095 | 4,005 | 4,050 | 4,050 | 4,050 | 4,500 | 4,500 | 4,500 | 4,500 | 4,455 | |
| Reservoir EOM | 4,230 | 4,095 | 4,005 | 4,050 | 4,050 | 4,050 | 4,500 | 4,500 | 4,500 | 4,500 | 4,455 | 4,365 | |
| Avg. Reservoir Content | 4,298 | 4,163 | 4,050 | 4,028 | 4,050 | 4,050 | 4,275 | 4,500 | 4,500 | 4,500 | 4,478 | 4,410 | |
| Avg.Head | 230 | 227 | 225 | 225 | 225 | 225 | 230 | 233 | 233 | 233 | 233 | 232 | |
| Gwh/mcm | 0.551 | 0.545 | 0.540 | 0.539 | 0.540 | 0.540 | 0.550 | 0.560 | 0.560 | 0.560 | 0.559 | 0.556 | |
| MW | 1182 | 1169 | 1158 | 1155 | 1158 | 1158 | 1180 | 1200 | 1200 | 1200 | 1198 | 1192 | |
| Gwh | 253 | 260 | 253 | 338 | 731 | 1189 | 774 | 703 | 398 | 293 | 281 | 263 | 5,737 |
| Full gate Gwh | 863 | 853 | 845 | 843 | 845 | 845 | 861 | 876 | 876 | 876 | 874 | 870 | |
| Plant factor % | 29 | 30 | 30 | 40 | 86 | 141 | 90 | 80 | 45 | 33 | 32 | 30 | |
| **Kambarata #2** | | | | | | | | | | | | | |
| Inflow | 459 | 477 | 469 | 628 | 1,353 | 2,201 | 1,407 | 1,256 | 711 | 523 | 503 | 474 | |
| Outflow | 459 | 477 | 469 | 628 | 1353 | 2201 | 1407 | 1256 | 711 | 523 | 503 | 474 | |
| Gwh/mcm | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| MW | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | |
| Gwh | 55 | 57 | 56 | 75 | 162 | 264 | 169 | 151 | 85 | 63 | 60 | 57 | 1,256 |
| Full Gate Output | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 | |
| Plant Factor | 13 | 13 | 13 | 17 | 37 | 60 | 39 | 34 | 19 | 14 | 14 | 13 | |
| Tributary Inflow mcm | 77 | 13 | 26 | 15 | 191 | 289 | 423 | 183 | 79 | 161 | 54 | 50 | 1,560 |
| **Toktogul** | | | | | | | | | | | | | |
| Inflow mcm | 536 | 490 | 495 | 643 | 1544 | 2490 | 1830 | 1439 | 790 | 684 | 557 | 524 | 12,022 |
| Outflow mcm | 905 | 905 | 1016 | 706 | 1250 | 1300 | 1300 | 1250 | 694 | 798 | 905 | 993 | 12,022 |
| Reservoir BOM | 18,000 | 17,631 | 17,216 | 16,695 | 16,632 | 16,926 | 18,116 | 18,646 | 18,835 | 19,000 | 18,886 | 19,000 | |
| Reservoir EOM | 17,631 | 17,216 | 16,695 | 16,632 | 16,926 | 18,116 | 18,646 | 18,835 | 18,931 | 18,886 | 19,400 | 18,531 | |
| Avg. Reservoir Content | 17,816 | 17,424 | 16,956 | 16,664 | 16,779 | 17,521 | 18,381 | 18,741 | 18,883 | 18,943 | 19,143 | 18,766 | |
| Head | 168 | 166 | 164 | 163 | 163 | 167 | 171 | 172 | 173 | 173 | 174 | 173 | |
| Gwh/mcm | 0.403 | 0.398 | 0.393 | 0.390 | 0.391 | 0.399 | 0.409 | 0.413 | 0.415 | 0.416 | 0.418 | 0.414 | |
| MW | 1096 | 1072 | 1043 | 1025 | 1033 | 1078 | 1131 | 1153 | 1162 | 1166 | 1178 | 1155 | |
| Gwh | 365 | 361 | 399 | 275 | 489 | 519 | 532 | 517 | 288 | 332 | 378 | 411 | 4,865 |
| Plant Factor | 46 | 46 | 52 | 37 | 65 | 66 | 64 | 61 | 34 | 39 | 44 | 49 | |
| | | | | | | | | | | | Summer | | 6,500 |
| **Kurpsai** | | | | | | | | | | | | | |
| Inflow mcm | 905 | 905 | 1016 | 706 | 1250 | 1300 | 1300 | 1250 | 694 | 798 | 905 | 993 | 12,022 |
| Gwh/mcm | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | 0.221 | |
| MW | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | |
| Gwh | 200 | 200 | 225 | 156 | 276 | 287 | 287 | 276 | 153 | 176 | 200 | 219 | 2,657 |
| Tributary Inflow mcm | 50 | 45 | 71 | 181 | 262 | 211 | 131 | 76 | 55 | 52 | 52 | 44 | 1,230 |
| **Tashkumyr** | | | | | | | | | | | | | |
| Inflow mcm | 955 | 950 | 1087 | 887 | 1512 | 1511 | 1431 | 1326 | 749 | 850 | 957 | 1037 | 13,252 |
| Gwh/mcm | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | 0.127 | |
| MW | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | |
| Gwh | 121 | 121 | 138 | 113 | 192 | 192 | 182 | 168 | 95 | 108 | 122 | 132 | 1,683 |
| **Shamaldysai** | | | | | | | | | | | | | |
| Inflow mcm | 955 | 950 | 1087 | 887 | 1512 | 1511 | 1431 | 1326 | 749 | 850 | 957 | 1037 | 13,252 |
| Gwh/mcm | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | |
| MW | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | |
| Gwh | 59 | 59 | 67 | 55 | 94 | 94 | 89 | 82 | 46 | 53 | 59 | 64 | 822 |
| **Uch Kurgan** | | | | | | | | | | | | | |
| Inflow mcm | 955 | 950 | 1087 | 887 | 1512 | 1511 | 1431 | 1326 | 749 | 850 | 957 | 1037 | 13,252 |
| Gwh/mcm | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | |
| MW | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | |
| Gwh | 67 | 67 | 76 | 62 | 106 | 106 | 100 | 93 | 52 | 60 | 67 | 73 | 928 |
| Cascade | 812 | 807 | 905 | 661 | 1,157 | 1,198 | 1,190 | 1,136 | 635 | 728 | 826 | 899 | 10,954 |
| Total Hydro GWh | 1,120 | 1,124 | 1,215 | 1,075 | 2,050 | 2,651 | 2,133 | 1,990 | 1,119 | 1,084 | 1,167 | 1,219 | 17,946 |
| Hydro Capacity MW | 4,548 | 4,511 | 4,471 | 4,451 | 4,460 | 4,506 | 4,581 | 4,623 | 4,632 | 4,636 | 4,646 | 4,617 | |

## SUMMARY ALTERNATIVE D: T55/RA

| | J | F | M | A | M | J | J | A | S | O | N | D | TOTALS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | ANNUAL | WINTER | SUMMER |
| Total Hydro GWh | 1,120 | 1,124 | 1,215 | 1,075 | 2,050 | 2,651 | 2,133 | 1,990 | 1,119 | 1,084 | 1,167 | 1,219 | 17,946 | 6,929 | 11,017 |
| Hydro Capacity MW | 4,548 | 4,511 | 4,471 | 4,451 | 4,460 | 4,506 | 4,581 | 4,623 | 4,632 | 4,636 | 4,646 | 4,617 | | | |
| **2010 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,485 | 1,485 | 1,315 | 1,055 | 768 | 742 | 742 | 742 | 755 | 1,146 | 1,302 | 1,485 | 13,024 | 8,218 | 4,806 |
| Hydro Surplus | 0 | 0 | 0 | 20 | 1,281 | 1,909 | 1,391 | 1,247 | 363 | 0 | 0 | 0 | 6,191 | | |
| Thermal Deficit | 365 | 361 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 62 | 135 | 266 | 1,289 | 1,289 | 0 |
| Supplied by Fuel Imports | 250 | 250 | 100 | | | | | | | 62 | 135 | 250 | 1,048 | 1,048 | 0 |
| Supplied by Energy Imp | 115 | 111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 127 | 127 | 0 |
| Annual Surplus | | | | | | | | | | | | | 4,903 | | |
| **2010 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand | 3,129 | 3,129 | 2,772 | 2,628 | 1,914 | 1,849 | 1,849 | 1,849 | 1,881 | 2,415 | 2,745 | 3,129 | | | |
| Surplus Capacity | 1,419 | 1,382 | 1,699 | 1,823 | 2,546 | 2,657 | 2,732 | 2,774 | 2,750 | 2,220 | 1,901 | 1,488 | | | |
| **2015 Energy Balance** | | | | | | | | | | | | | | | |
| KYG Energy Demand | 1,584 | 1,584 | 1,403 | 1,125 | 820 | 792 | 792 | 792 | 806 | 1,223 | 1,389 | 1,584 | 13,893 | 8,766 | 5,127 |
| Hydro Surplus | 0 | 0 | 0 | 0 | 1,230 | 1,859 | 1,341 | 1,198 | 313 | 0 | 0 | 0 | 5,941 | | |
| Thermal Deficit | 464 | 460 | 188 | 51 | 0 | 0 | 0 | 0 | 0 | 139 | 222 | 365 | 1,888 | 1,837 | 51 |
| Supplied by Fuel Imports | 250 | 250 | 188 | 170 | | | | | | 139 | 222 | 250 | 1,469 | 1,299 | 170 |
| Supplied by Energy Imp | 214 | 210 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 115 | 538 | 538 | 0 |
| Annual Surplus | | | | | | | | | | | | | 4,053 | | |
| **2015 Capacity Balance** | | | | | | | | | | | | | | | |
| KYG Peak Demand MW | 3,338 | 3,338 | 2,957 | 2,372 | 1,727 | 1,669 | 1,669 | 1,669 | 1,698 | 2,577 | 2,928 | 3,338 | | | |
| Surplus Capacity | 1,210 | 1,173 | 1,514 | 2,079 | 2,733 | 2,837 | 2,912 | 2,954 | 2,934 | 2,059 | 1,718 | 1,279 | | | |

## ANNEX E: KAMBARATA # 2 WITHOUT KAMBARATA # 1

| | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kambarata # 2** | | | | | | | | | | | | | |
| Inflow | 324 | 342 | 379 | 673 | 1353 | 2201 | 1857 | 1256 | 711 | 523 | 458 | 384 | 10,463 |
| Outflow | 324 | 342 | 379 | 673 | 1353 | 2201 | 1857 | 1256 | 711 | 523 | 458 | 384 | |
| GWh/mcm | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| MW | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | |
| GWh | 39 | 41 | 46 | 81 | 162 | 264 | 223 | 151 | 85 | 63 | 55 | 46 | 1,256 |
| Full Gate Output | 256 | 256 | 256 | 256 | 256 | 256 | 256 | 256 | 256 | 256 | 256 | 256 | |
| Plant Factor | 15 | 16 | 18 | 32 | 64 | 103 | 87 | 59 | 33 | 25 | 22 | 18 | |

# ANNEX F: KAMBARATA #1 ESTIMATE

| | Revised with data from Ertan | | | | | Harza 1993 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Unit | Unit Price (US$) | Amount US$ | Explanation of Revision | Quantity | Unit | Unit Price (US$) | Amount US$ |
| Preparatory Works | 1 | LS | 35,000,000 | 35,000,000 | Ertan Unit Lump Sum | 1 | LS | 27,000,000 | 27,000,000 |
| Diversion and Care of Water | 1 | LS | 15,000,000 | 15,000,000 | Ertan Unit Lump Sum*.7 | 1 | LS | | |
| Common Excavation | 655,900 | cu M | 6.0 | 3,935,400 | Ertan Unit Price | 655,900 | cu M | 1.1 | 721,490 |
| Open Rock Excavation | 5,413,200 | cu M | 8.6 | 46,553,520 | Ertan Unit Price | 5,413,200 | cu M | 4.1 | 22,194,120 |
| Underground Excavation | 214,700 | cu M | 86.0 | 18,464,200 | Ertan Unit Price | 214,700 | cu M | 56.0 | 12,023,200 |
| Shaft Excavation | 23,500 | cu M | 60.0 | 1,410,000 | Ertan Unit Price | 23,500 | cu M | 77.0 | 1,809,500 |
| Backfill | 490,200 | cu M | 2.1 | 1,029,420 | Ertan Unit Price | 490,200 | cu M | 2.1 | 1,029,420 |
| Powerhouse Concrete | 163,800 | cu M | 87.0 | 14,250,600 | Ertan Unit Price | 163,800 | cu M | 100.0 | 16,380,000 |
| Dam and SpillwayConcrete | 3,521,900 | cu M | 66.0 | 232,445,400 | Ertan Unit Price | 3,521,900 | cu M | 110.0 | 387,409,000 |
| Other Reinforced Concrete | 228,800 | cu M | 120.0 | 27,456,000 | Ertan Unit Price | 228,800 | cu M | 220.0 | 50,336,000 |
| Underground Concrete | 94,500 | cu M | 130.0 | 12,285,000 | Ertan Unit Price | 94,500 | cu M | 241.0 | 22,774,500 |
| Grouting | | LS | 27,300,000 | 27,300,000 | Harza Lump Sum | 1 | LS | 27,300,000 | 27,300,000 |
| Steel Liners | 12,700 | ton | 3,360 | 42,672,000 | Ertan Unit Price | 12,700 | ton | 2,062 | 26,187,400 |
| Structural Steel | 10,400 | ton | 2,106 | 21,902,400 | Harza Unit Price | 10,400 | ton | 2,106 | 21,902,400 |
| Rockbolts | | | | | Included in Excavation | 1,156 | ton | 3,310 | 3,826,360 |
| Turbine/Generator/Transformer | 1,200 | MW | 120,000 | 144,000,000 | Ertan Cost/MW | 1,700 | MW | 220,000 | 374,000,000 |
| Misc.Mechanical & Electoral | 1 | LS | 16,000,000 | 16,000,000 | Harza LS | 1 | LS | 16,000,000 | 16,000,000 |
| Gates,Cranes and Hoists | 1 | LS | 37,000,000 | 37,000,000 | Harza LS | 1 | LS | 37,000,000 | 37,000,000 |
| Switchyard | 1 | LS | 12,000,000 | 12,000,000 | Harza LS | 1 | LS | 12,000,000 | 12,000,000 |
| Substation | 1 | LS | 20,000,000 | 20,000,000 | Harza LS | 1 | LS | 20,000,000 | 20,000,000 |
| 500 kv Transmission Line | 260 | km | 400,000 | 104,000,000 | Ertan $/km | 706 | km | 374,000 | 264,044,000 |
| Base Cost | | | | 832,703,940 | | | | | 1,343,937,390 |
| Contingencies | 20% of Civil Works | | | 99,940,788 | | 25% of total | | | 335,984,348 |
| Engineering and Administration | 7% of Total | | | 65,285,131 | | 10% of total | | | 167,992,174 |
| TOTAL | | | | 997,929,859 | | | | | 1,847,913,911 |
| In 2002 constant dollars(No change in MUV 1990 to 2000) | | | | 997,929,859 | | | | | |
| Add 20% ( conditions less favorable than China) | | | | 1,197,515,830.75 | | | | | |

# ANNEX F: KAMBARATA #2 ESTIMATE

| | Revised with data from Ertan | | | | | Harza 1993 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Unit | Unit Price (US$) | Amount US$ | Explanation of Revision | Quantity | Unit | Unit Price (US$) | Amount US$ |
| Preparatory Works | 1 | LS | 3,400,000 | 3,400,000 | Harza Lump Sum | 1 | LS | 3,400,000 | 3,400,000 |
| Diversion and Care of Water | 1 | LS | 5,000,000 | 5,000,000 | Estimate | | | | |
| Common Excavation | 538,000 | cu M | 6.0 | 3,228,000 | Ertan Unit Price | 538,000 | cu M | 1.1 | 591,800 |
| Open Rock Excavation | 12,300 | cu M | 8.6 | 105,780 | Ertan Unit Price | 12,300 | cu M | 4.1 | 50,430 |
| Underground Excavation | 215,300 | cu M | 86.0 | 18,515,800 | Ertan Unit Price | 215,300 | cu M | 56.0 | 12,056,800 |
| Embankment | 1,296,000 | cu M | 3.4 | 4,406,400 | Harza Unit Price | 1,296,000 | cu M | 3.4 | 4,406,400 |
| Backfill | 507,100 | cu M | 2.1 | 1,064,910 | Ertan Unit Price | 507,100 | cu M | 1.1 | 557,810 |
| Powerhouse Concrete | 198,900 | cu M | 87.0 | 17,304,300 | Ertan Unit Price | 198,900 | cu M | 150.0 | 29,835,000 |
| Underground Concrete | 94,500 | cu M | 130.0 | 12,285,000 | Ertan Unit Price | 157,800 | cu M | 230.0 | 36,294,000 |
| Grouting | 158,000 | LS | 38 | 6,004,000 | Harza Unit Price | 158,000 | sq M | 38 | 6,004,000 |
| Steel Liners | 5,510 | ton | 3,360 | 18,513,600 | Ertan Unit Price | 5,510 | ton | 2,062 | 11,361,620 |
| Structural Steel | 300 | ton | 2,106 | 631,800 | Harza Unit Price | 300 | ton | 2,106 | 631,800 |
| Galvanized Steel | 590 | ton | 3,000 | 1,770,000 | Harza Unit Price | 590 | ton | 3,000 | 1,770,000 |
| Rockbolts | 803 | | 3,310 | 2,657,930 | Harza Unit Price | 803 | ton | 3,310 | 2,657,930 |
| Turbine/Generator | 400 | MW | 130,000 | 52,000,000 | Ertan $/MW | | | | |
| Transformers | 2 | each | 1,200,000 | 2,400,000 | | 2 | each | 1,200,000 | 2,400,000 |
| Generators | | | | | | 2 | each | 9,600,000 | 19,200,000 |
| Misc.Mechanical | 1 | LS | 11,600,000 | 11,600,000 | Harza Lump Sum | 1 | LS | 11,600,000 | 11,600,000 |
| Misc. Electrical | 1 | LS | 2,160,000 | 2,160,000 | Harza Lump Sum | 1 | LS | 2,160,000 | 2,160,000 |
| Gates,Cranes and Hoists | 1 | LS | 12,836,000 | 12,836,000 | Harza Lump Sum | 1 | LS | 12,836,000 | 12,836,000 |
| Switchyard | 1 | LS | 6,000,000 | 6,000,000 | Harza Lump Sum | 1 | LS | 6,000,000 | 6,000,000 |
| 500 kv Transmission Line | 47 | km | 374,000 | 17,578,000 | Harza $/km | 47 | km | 374,000 | 17,578,000 |
| Subtotal | | | | 199,461,520 | | | | | 181,391,590 |
| Contingencies | 20% of Civil Works | | | 18,977,504 | | 30% Civil Works and 20% of other items | | | 51,807,000 |
| Engineering and Administration | 7% of Total | | | 15,290,732 | | 10% of total | | | 25,536,000 |
| TOTAL | | | | 233,729,756 | | | | | 258,734,590 |
| In 2002 constant dollars(No change in MUV 1990 to 2000) | | | | 233,729,756 | | | | | |
| Add 20% ( conditions less favorable than China) | | | | 280,475,706.82 | | | | | |

**Estimate for 600 MW**

Additional Costs:

| | | | | |
|---|---|---|---|---|
| Turbine/Generator | 200 | MW | 130,000 | 26,000,000 |
| Transformers | 1 | each | 1,200,000 | 1,200,000 |
| Misc.Mechanical | 1 | LS | 5,000,000 | 5,000,000 |
| Misc. Electrical | 1 | LS | 1,000,000 | 1,000,000 |
| Civil Works (in contingency &eng.) | | | | 10,000,000 |
| Subtotal | | | | 43,200,000 |
| TOTAL | | | | 323,675,706.82 |